

NATIONAL ENERGY POLICY ACT OF 1989
(Energy Efficiency and Renewable Energy)

HEARING
BEFORE THE
COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE
ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON

S. 324

**TO ESTABLISH A NATIONAL ENERGY POLICY TO REDUCE GLOBAL
WARMING, AND FOR OTHER PURPOSES**

MARCH 14, 1989

PART 1



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NATIONAL ENERGY POLICY ACT OF 1989

(Energy Efficiency and Renewable Energy)

TUESDAY, MARCH 14, 1989

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 9:38 a.m., in room SD-366, Dirksen Senate Office Building, Hon. J. Bennett Johnston, chairman, presiding.

OPENING STATEMENT OF HON. J. BENNETT JOHNSTON, U.S. SENATOR FROM LOUISIANA

The CHAIRMAN. The hearings will come to order.

I am pleased to welcome you to this morning's hearings to receive testimony on current U.S. programs and energy conservation and renewable energy research and development. Today's hearing is designed to aid the committee in its understanding of the contribution these resources and technologies are likely to make in reducing emissions of carbon dioxide and other trace greenhouse gases.

Energy efficiency and renewable alternative energy sources will play an important role in helping the United States meet the energy needs of an expanding economy. Innovative policies are necessary not only to meet the domestic energy needs of this Nation, but to address the environmental and social problems posed by the greenhouse effect, acid rain and the destruction of the ozone layer. As policymakers, we must begin to seriously examine possible strategies for minimizing the rates of future greenhouse gas emissions while promoting sustained economic growth.

Energy efficiency will remain key to a sensible domestic energy policy both to reduce this Nation's dependence on imported oil and to control emissions of CO₂ and trace gases caused by the combustion of fossil fuels. Carbon emissions may also be reduced through the use of non-fossil renewable energy sources such as photovoltaics, wind, hydropower, geothermal and nuclear. With improvements and reliability and economies of scale, renewable energy sources are displacing carbon-based fuels for many traditional energy needs.

It is important to note that the Senate Committee on Energy and Natural Resources will play one of the leading roles in formulating policies to respond to these environmental and economic challenges. The committee will continue to take the initiative in evaluating energy research and development priorities, in determining

policies for efficiency and conservation, and for coordinating a national energy policy for global warming.

I look forward to receiving today's testimony on energy efficiency, renewables and S. 324, the National Energy Policy Act of 1989, and thank the witnesses for their time and participation.

I wanted at this point to say a lot of nice things about Senator Tim Wirth from Colorado who has been a real leader on global warming, but unfortunately Senator Wirth chose to contribute to the problem by being out there in traffic right now rather than to be part of the solution. [Laughter.]

And so, when he comes in, if everyone would remind him that he had his chance to advance in the sunlight as opposed to getting all of our opprobrium and criticism. That is his fault and not ours.

Senator Bumpers, would you like to either praise or criticize Senator Wirth at this point? [Laughter.]

STATEMENT OF HON. DALE BUMPERS, U.S. SENATOR FROM ARKANSAS

Senator BUMPERS. Do I have to use all my time for an opening statement on Tim Wirth? [Laughter.]

Mr. Chairman, I don't have any formal remarks. I just want to say that the potential damage that can be caused to the planet by this problem is so ominous it just boggles the mind. And yet, the propensity of Congress has always been to duck these kinds of tough choices until the die is cast.

We had an opportunity back in 1975 and 1976 because of the brilliant leadership of this Senator to do something about the ozone layer. We had hearings then. Every atmospheric scientist in the country came in and said, yes, the ozone depletion theory is a perfectly valid theory and probably correct. But when Senator Packwood and I tried to correct the problem by banning CFCs back then, we got the wholesome total of 33 votes. It was just a simple case that the chemical industry had a lot more clout than we had. And so, now we are 12 years back from where we could have been then.

And, indeed, it is the western Europeans who have had to set the pace for us on ozone by saying by the turn of the century under the Montreal Protocol, we ought to reduce CFCs and other ozone-depleting causes. We ought not to wait and just cut by 50 percent. We ought to cut all of them. And it is our western European friends who are taking the lead in this now, though they were slow to get to it.

And now one of my primary concerns about this global warming problem is I believe the theory, but even if the theory turns out to be incorrect, every single thing we are proposing to do under this legislation is good public policy. It ought to be done anyway. But if it turns out that the global warming theory is a correct theory and we have done nothing then, of course, our children and grandchildren can fairly accuse us of again ducking the tough choices, not just jeopardizing their quality of life, but ducking the possibility that they may not even exist.

If you look at all the studies, you will find that the food supply in the United States, the so-called bread basket of the world, may be

cut so dramatically that we cannot even afford to feed our own people.

So, when you consider things like that and you consider the fact that the solutions are known, they are viable, they are doable, and that the only thing that will keep us from dealing with this is two things: number one, Congress' absolute unwillingness to make the tough choices and, secondly, our inability to get international cooperation because it is not just a United States' problem. It is an international problem.

So, I am going to Brazil this weekend. Senator Wirth has already been down there and stirred up a revolution. [Laughter.]

I am going to go try and ameliorate the damage he did while he was down there.

The CHAIRMAN. He will never be late again in this committee. [Laughter.]

Senator HEINZ. Senator, not a chance of you ameliorating.

Senator BUMPERS. Well, they tell me if we think we have an aggressive press, you only have to visit Brazil.

But even so, we are not trying to impinge on Brazil's sovereignty, and some of us have made that very plain. We do not want to and we cannot. And the only thing we can do is to say to Brazil that we hope we can come up with some kind of an international cooperative agreement which will be much more beneficial to you and mutually beneficial to the rest of the planet so that it is a good deal for everybody.

But I know in visiting with President Sarney, which our delegation hopes to do, he is going to say two things. Number one, this is all well and good for you people up there in the north in the United States. You have already cut your forests. You have already had a good deal. We are a developing nation. We have 40 million people after the war. Now we have 140 million. And we have economic problems of our own, a \$120 billion debt. And you are coming down here to tell us how to run our business. We don't want to do that, but I can certainly understand his response.

And the other thing he is going to say is 40 percent of the problem is coming out of the exhaust of your automobiles. Why don't you go back up there and tend to your own business and do something about the problem in the United States before you come down here and start lecturing us about the rain forest? That is all perfectly legitimate.

So, all I am saying is I hope that we can reach legitimate international agreements, as well as pass legislation to show the rest of the world we are willing to take the lead on what I consider probably, next to the nuclear arms race, the most ominous problem.

I told my wife, who is a peacenik, that she ought just—we haven't had a nuclear war—declare victory and quit, also to remind her that the nuclear annihilation threat may not be as great today as slowly choking to death on the pollution of the world and the effects of the greenhouse.

Now, that is not all said to be all that ominous. What I am saying is, ending on a hopeful note, there are solutions to this and we ought to take advantage of those solutions.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Bumpers.

Our ranking member, Senator McClure?

**STATEMENT OF HON. JAMES A. McCLURE, U.S. SENATOR FROM
IDAHO**

Senator McCLURE. Mr. Chairman, thank you. I will ask that my opening statement be made a part of the record at this point.

The CHAIRMAN. Without objection.

Senator McCLURE. And I will add to it only just this much.

While it is possible that we might do very much that is good, it is also quite possible that we would do things that are not. That is the challenge for us and for the Congress to sort through the opportunities and make certain that we don't make mistakes in doing it because there are obvious opportunities to improve the situation for the globe. And it is a global problem, not just a U.S. problem. Some of the opportunities are only in the U.S. Some we can only reach ourselves through our policies, and we cannot directly affect those of other nations, even though we should try.

There are also very great consequences to some of the decisions that we might make. And it is not always a win-win situation. Some may give us that opportunity, but others may also create some dangers and create some problems as we seek solutions.

I would remind those who have been here a long while, as I have, to remember some of the mistakes we have made in the past so that we don't do it again, and also to remind ourselves that we have made those mistakes in the past, and sometimes we would have if we had acted as we were urged at times, which is just a word of caution that just doing something is not necessarily doing something good.

Thank you.

[The prepared statement of Senator McClure follows:]

**OPENING STATEMENT
SENATOR JAMES A. McCLURE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
TUESDAY, MARCH 14, 1989 (9:30 A.M.)**

NATIONAL ENERGY POLICY ACT (S. 324)

Good morning. I wish to thank the chairman for convening these hearings on the future role of energy efficiency improvements and renewable energy sources in our national energy strategy. Clearly such energy technologies must play an important and critical role in any national energy policy and should be considered in that context.

Last year, many of the subjects under discussion today were considered as a part of the Committee's continuing hearings on the status of current knowledge regarding global climate changes and, in particular the "greenhouse effect". At that time, testimony was received from a number of expert scientists in this critical area.

Climate changes can have a great influence on human society. Precisely because their implications are global, such climate changes should be of international concern. But what is clear is that there is no single cause and no single policy initiative that will completely mitigate current trends.

As expected, S. 324 addresses several energy and natural resource matters which are encompassed by the jurisdiction of the Committee. Many of issues dealt with represent the elements in any comprehensive national energy policy, even if we were not concerned with the effects of fossil fuel usage on global climate change.

S. 324 contains fifteen titles, ranging from research and development to a requirement for a least-cost national energy plan, to programs to moderate world population growth. Each of the proposals has its own strengths and weaknesses. Each raises different energy and environmental policy issues.

In contrast to last year's hearings, today's hearings are beginning to focus on policy alternatives to improve energy efficiency and on current research programs on energy conservation and renewable energy. Some of the proposals are similar, if not identical, to those contained in other legislation pending before the Committee. Others may not even be within the jurisdiction of the Committee.

Nevertheless, I look forward to participating with the Chairman in the evolution of this legislation and I would urge the chairman to expand these hearings to include, in particular, testimony on the regulatory provisions of S. 324. These provisions raise many of the same issues as those currently being addressed by the Federal Energy Regulatory Commission and we are all aware of the controversy that surrounds the recent FERC proposals to begin to restructure our domestic electric utility industry.

From this perspective I look forward to the testimony from today's witnesses.

The CHAIRMAN. Thank you, Senator McClure.
Senator Burns?

STATEMENT OF HON. CONRAD BURNS, U.S. SENATOR FROM
MONTANA

Senator BURNS. Thank you, Mr. Chairman, and good morning. In the essence of time, I would ask that my opening remarks be made a part of the record.

The CHAIRMAN. Without objection.

Senator BURNS. I will shorten up a little bit. It seems like we are getting these opening statements, and we don't have any time to listen to the people we should be listening to. And we have two Senators sitting down there who are just champing at the bits and are ready to go.

I did want to say that I am pleased that we are going to forward the issue of research to improve the technology to create some alternative energy sources such as solar and nuclear and geothermal and hydropower. And also, I hope we will keep up our clean coal burning technology, as we are doing in Butte, Montana.

I understand the need for developing a comprehensive policy and moving ahead with vital research, but I hope we can maximize the use of tax incentives and other non-Federal sources of funding rather than depend entirely on Federal appropriations, especially in light of the current deficit.

I also believe in this issue especially we should not confuse it with issues in the bill of trying to address the question of land allocation in the Tongass National Forest. I think this issue is being considered in separate legislation, as it should be. It is a standalone item.

I would like to commend Senator Wirth. He has taken the point on this issue, and I think that we have many that come before Congress. None are as important as this is. It should be very high on the priority lists of each and every one of us.

That is my opening, and thank you, Mr. Chairman. We will get on with the business at hand.

[The prepared statement of Senator Burns follows:]

CONRAD BURNS
MONTANA

United States Senate
WASHINGTON, DC 20510

COMMITTEE
COMMERCE, SCIENCE, AND
TRANSPORTATION
ENERGY AND NATURAL RESOURCES
SMALL BUSINESS

COMMITTEE ON ENERGY AND NATURAL RESOURCES
HEARING ON S.324, NATIONAL ENERGY POLICY ACT OF 1989
by Senator Conrad Burns

Mr. Chairman. Energy use and energy conservation affects all of us. No matter what our political persuasion, every American must be concerned about our Nation's future energy security. As a nation, we have become complacent in our efforts to improve our energy efficiency and reduce our dependence on foreign sources of oil. Every day the disparity between what we produce and what we use becomes more profound. Every day we learn more about the damaging effects that high levels of carbon dioxide and other gases have on the atmosphere, global warming and acid rain.

All energy sources must be part of any comprehensive national energy policy. We cannot discount the tremendous importance of coal, our most abundant energy resource, nor can we fail to acknowledge our very real and very substantive need for oil and gas. They are essential components of our energy future. In addition, we must become much more fuel efficient than we currently are, and we must do more to clean up emissions from the fuels we burn. I am pleased to see that research to improve technology and to create alternative energy sources such as solar, nuclear, geothermal, and hydropower is encouraged. I hope

this will also continue to include clean burning coal technology being developed in Butte, Montana.

Although I understand the need for developing a comprehensive policy and moving ahead with vital research, I hope we can maximize the use of tax incentives and other non-federal sources of funding, rather than depend entirely on federal appropriations, especially in light of the current huge federal deficit.

I, however, do not believe we should confuse the issues in this bill by trying to address the question of land allocation in the Tongass National Forest. This issue is being considered in separate legislation, as it should be.

At this time, I would also like to commend the Senator from Colorado for his determination in moving forward with a National Energy Policy. I look forward to hearing the viewpoints of the various witnesses on this important issue.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Burns.
Senator Rockefeller.

**STATEMENT OF HON. JOHN D. ROCKEFELLER IV, U.S. SENATOR
FROM WEST VIRGINIA**

Senator ROCKEFELLER. Mr. Chairman, if I might just also commend Senator Wirth and other cosponsors of 324. Obviously, they have done a lot of work on the bill, and I think it puts before us a serious debate, which is what this subject needs. One cannot pretend that the problem does not exist. It does exist. We need a serious debate. Energy policy has been, with the exception I believe of the methanol bill, which this Congress passed last year, entirely and totally neglected for some 10 years now. And that obviously has troubling consequences for our security as well as for our economic prospects.

The issues raised by S. 324 are very complex, and I would have to say, in all fairness, I think the Congress is going to have to address them very carefully. I look forward to this process so that we can see whether this bill, some other bill or some combination of bills are required.

S. 324 is an ambitious bill, and that is commendable. I will be raising a number of questions as we go along. In a sense, I suppose I will be asking whether or not this bill is ambitious enough. Does it take a long enough view? Is it sufficiently balanced in terms of the natural resources that are involved? Does it take into account, for example, the impact of energy policy on enough factors? And one of those factors I think might fairly be described as jobs, and jobs as well as an energy independent nation and the environmental concerns of the Nation which are highly and substantially legitimate.

I thank the Chairman.

The CHAIRMAN. Senator Wallop.

**STATEMENT OF HON. MALCOLM WALLOP, U.S. SENATOR FROM
WYOMING**

Senator WALLOP. Mr. Chairman, thank you for holding the hearing today. I might observe that the Energy Committee is off to a slow start on this issue. My office is down the hall from the Commerce Committee, and I noticed several weeks ago that they had their full-media event down there on this subject. And it is obvious that global warming has become the hot environmental issue as we enter the final decade of this century.

I must say also that I recall that the greenhouse effect was forecast by the National Academy of Sciences in 1978 to be causing the beginning of the new ice age, and it was stated that it was none too soon to begin to prepare for that. But since the long, hot, dry summer of 1988, public concern has been aroused by the threat of warming from the greenhouse effect, and we are now in that phase of public policy debate that one expert has called the greenhouse climate of fear being coerced by the force of trendiness to express alarm over some new ecological disaster. I do not want to be stampeded into policymaking by a climate of fear. Where I come from, stampedes are irrational flights from the unknown which lead to

disaster. As we hold these hearings and debate this matter, it is my hope that we balance our fears with a prudent and healthy dose of caution and skepticism.

Current anxiety about global warming reflects a very rough summer and some equally rough computer modeling. Over the past couple of years, this committee has held hearings with the scientists who developed the models for measuring climate change. And I recall back in the 1970s, another computer model was developed predicting environmental doom. The Club of Rome predicted the global pollution and exhaustion of resources and the doom of the human race. Although the club exists still, they have scrapped that computer modeling.

I realize that we are approaching the point where a computer can defeat the best chess masters in the world. However, they are still only as good as their programs. And climate modeling has many gaps, and the ability to predict is not an exact science. In fact, we cannot even agree on what has already happened.

In January news stories indicated that some scientists were rethinking the question of whether the earth's temperature had risen, indeed, over the past 150 years, and then an environmental scientist at the University of Virginia, Patrick Michaels, strongly criticized the global warmers in a recent Washington Post article. My guess is, Mr. Chairman, it would be useful to have a hearing to explore some of these divergent views on the process.

Today's hearings focus on energy efficiency and technology, as well as tools to reduce global warming. Both issues are tied into a Federal role, particularly from the budget perspective. Western states have already been burned by the Federal clean coal project. So, we naturally have some skepticism about advancing the Federal role in private sector activities. One witness will argue today the private sector is developing energy efficiency programs. Listen to the radio here in Washington and you can learn how you can save \$45 on your summer electric bill by joining the utility's load management program.

I would also suggest two proposals to reduce carbon dioxide emission, the main culprit in the global climate change. If you burn fossil fuels with 100 percent efficiency, the result will be carbon dioxide. And the fact is the more efficient the burning, the more the carbon dioxide. If we want to improve the mix of fuels used for power generation, we could first consider the decontrol of natural gas which would expand the production of this clean burning fuel.

Second, we must reduce the regulatory hurdles that block the building of nuclear power. New reactor designs show great promise for a power source which produces no carbon dioxide. We have developed an anti-nuclear mind set which has virtually stalled this use of a power source. It is interesting that those who so strongly oppose nuclear power must now consider it as a viable energy resource.

We also need to be flexible in the solutions we develop to reduce the so-called greenhouse gases. We will learn that scrubbers mandated to reduce sulfur dioxide increase carbon dioxide emissions. We are going through the process of renewing the Clean Air Act, and one of the most bitter debates will be over mandating one tech-

nology. It is my hope that we will realize that rigidity in solutions is not always the most sensible policy.

Just last week in the Washington Post, we learned that our environmental solutions occasionally have some dysfunctional results. Twenty-five years of research in New Hampshire streams has produced disturbing results. Researchers speculate that pollution control practices have not only significantly reduced acidic compounds and reduced the acidity in the rain that falls, but they at the same time have reduced the alkaline buffers. Sulfur in the streams has dropped, but so has the calcium, potassium and other alkalines, so the acid content has remained steady. We may now have to devise a method for putting the buffers back in the atmosphere.

Mr. Chairman, my plea is that we combine healthy skepticism, some caution and the intellectual flexibility as we explore this very complicated problem. There is no question that we must pay attention to it. The attention that we pay must bear some result that is intended and not unintended.

I thank the Chair.

The CHAIRMAN. Senator Wirth, in your absence, I tried to say a word or two of praise of you. [Laughter.]

Under Bumpers' slashing attack, I was unsuccessful. As you read the record, I am sure you will never be late again. [Laughter.]

STATEMENT OF HON. TIMOTHY E. WIRTH, U.S. SENATOR FROM COLORADO

Senator WIRTH. Thank you very much, Mr. Chairman. I would not have polluted as much had I had an energy efficient automobile or one as efficient as the standards of this bill would suggest we ought to have.

I thank you very much for your very fine leadership on this issue of global warming and overall environmental issues. We have just begun in this committee. This is the first of a series of hearings, and I appreciate the great record that we had last year. The unprecedented and historic hearing that we had with Dr. Hansen on global warming I think probably was as important a single event as has occurred on the Hill on this important issue.

It is my belief, Mr. Chairman, as you know, that we are embarking on a decade in which environmental issues simply verge on overwhelming, that if we are not careful and if we do not take action now, environmental systems that are currently stretched may well break, and that we are going to be in for some very rude surprises and some very significant changes in the very systems that support life on this earth.

It is our responsibility to move rapidly and to move aggressively and to move as well with prudence. And you have certainly done that in the way in which you have launched this committee. I thank you very much for your great support of these efforts.

This is the first of a series of hearings that we will be having. The one today focuses on energy efficiency. And if Senator Wallop and others are correct that, in fact, there is little for us to be worried about at this point, what we are embarking upon today is important to do anyway. Energy efficiency is good for the economy. Energy efficiency is good for our trade situation. Energy efficiency

is sound for our situation around the world. And even if there is no problem at all, we ought to be pursuing the energy efficiency strategies that are going to be described by our witnesses today.

So, I hope that at least, Mr. Chairman, we can move very rapidly on this energy efficiency package, and I would hope that the other pieces would come along behind.

Again, thank you very much, and I want to particularly thank as well Senator Heinz and Senator Fowler who, with Senator Bumpers, have been very, very helpful in helping to glue together this piece of legislation. Thank you, Mr. Chairman.

[The prepared statement of Senator Wirth follows:]

STATEMENT OF THE HONORABLE TIMOTHY E. WIRTH

March 14, 1989

The global warming issue and associated public policy debates are rapidly gaining momentum. Around the world, initiatives are being developed -- from the international to the local level -- to address this enormous challenge. Here in the United States, and in the U.S. Senate, public policy initiatives are maturing quickly.

I believe that now is the time to get our hands dirty and go to work. As Secretary of State Baker said several weeks ago, we cannot afford to wait for all the answers about the global warming trend. Instead, Secretary Baker urged that we act now to increase energy efficiency and develop alternatives as part of a strategy to prevent climatic chaos.

We already know that we are committed to climate change. The gases already generated by man will change the climate. The question that remains is how much change we have in store. In fact, there is compelling evidence that climate change is already underway.

Last year, it was here in this Committee that Dr. James Hansen of NASA delivered his stunning and historic testimony contending that the global warming is underway. The assault on the atmosphere has gone on for too long and people around the world realize it. We must address this enormous challenge and prevent disruptive climate change in order to preserve the climatic predictability expected by the citizens of the world and for future generations.

The purpose of today's hearing is to examine the role of energy efficiency and renewable energy technologies as part of a global warming action plan. We know that it makes good economic and energy sense to improve the efficiency of energy use. And it is clear that energy efficiency must be the top priority of efforts to protect the atmosphere. Renewable energy also offers the United States with an opportunity to improve its competitiveness, enhance its energy security and reduce emissions of greenhouse gases.

In the near future, however, energy efficiency and renewable energy will not be enough to sustain economic growth and reduce the United States contribution of greenhouse gases. Instead, we need a comprehensive national energy policy that will reduce greenhouse gas production.

Fossil fuels will be with us for many years ahead, and it is almost unimaginable to envision a world without fossil fuels. However, we have to begin examining the mixture of fossil fuels in our energy stream to try to reduce harmful side effects of their use. In my opinion, we also have to reexamine the nuclear option to determine its future role. And we are going to have to deal with very difficult natural resource issues like deforestation and reforestation -- another area of interest to the committee. I hope to explore all of these

issues with my colleagues in this committee, its subcommittees and on other Senate panels.

Today, I hope that we can begin to get a clearer picture of the opportunities ahead to tap energy efficiency and renewable energy resources. It is my hope that this will be the beginning of a long and fruitful dialogue on energy and environmental policy and that we can act on S. 324 during the 101st Congress.

Our first panel today will explore the overall potential of energy efficiency and renewable energy resources to contribute to the nation's energy mix in the year's ahead.

The second panel will examine the current trends in energy efficiency and renewable energy research and development. Renewable energy and energy efficiency research budgets have been bulldozed during the past eight years, and are slated for further cuts again this year. I am confident that today's witnesses will help the committee understand the effects of current research and development trends and help us prioritize an agenda for future activity.

Finally, later today we will hear from a panel of regulatory experts to explore mechanisms that might provide the utility sector with incentives to pursue energy conservation and renewable energy sources more aggressively, and to earn a rate of return at the same time.

I want to thank all of our witnesses for coming -- especially Senators Fowler and Heinz who have been strong supporters of integrated energy and environmental strategies. Thank you all for coming.

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The CHAIRMAN. Thank you, Senator Wirth.
Senator Murkowski.

**STATEMENT OF HON. FRANK H. MURKOWSKI, U.S. SENATOR
FROM ALASKA**

Senator MURKOWSKI. Thank you, Mr. Chairman.

I hope that as we progress on the issue of global warming, we will address realistically our alternatives and recognize that the environmental community has been noticeably lax in addressing available alternatives.

I think it is extraordinary at this time we have a Secretary of Energy with the expertise and background of Admiral Watkins to address the advance technology of nuclear energy. I think as we look to alternatives, clean air—that is what comes to mind most immediately. And as we look at the technology that is being developed in Europe, and having had a chance to be with the Chairman over in France and seeing how they treat their nuclear waste by reprocessing it, where we still are back in the dark ages storing ours on site and basically ignoring the problem.

I think it reflects on some real decisions that are going to have to be made in a broad area as we address alternatives. And we don't want to see that technology transferred necessarily totally from the U.S., and we're going to have to face up to some hard decisions relative to the area of nuclear energy.

So, as we debate the merits of the exposure to global warming, which I think is something that, obviously, we have a very real and great concern about, we have to realistically ascertain the available alternatives that are within arm's length at least.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Murkowski.

Now we are pleased to welcome two Senators who have long been associated with the environment and who have been very interested in this particular subject. I am glad to welcome to the committee first Senator John Heinz from Pennsylvania.

**STATEMENT OF HON. JOHN HEINZ, U.S. SENATOR FROM
PENNSYLVANIA**

Senator HEINZ. Mr. Chairman, thank you very much. I want to commend you, Mr. Chairman, on holding this hearing on S. 324. And in particular I want to testify about one aspect of that legislation, namely, Senate Amendment No. 1, which deals with the fuel fleet efficiency standard.

But to put it all in perspective, let me tell you that I am concerned about global warming. I believe that the process known as the greenhouse effect has been well documented going back over 50 or 60 years, and that it does require that we take it seriously.

And when it comes to the question of what standard of proof we should use in judging whether the greenhouse effect is likely, highly likely or unlikely, I feel constrained to point out that if we in this body were to use the standard of beyond reasonable doubt before deciding that something needs to be dealt with, which is such a high standard of proof—indeed, it is the standard used in criminal trials—then we would never get anything done around

here. Politics, if you will, is not a criminal process. It is and ought to be a civil proceeding. And, therefore, I hope that we will use the standard of judgment of the preponderance of the evidence. And on global warming, I think the preponderance of the evidence is we have a problem.

Let me try and put the legislation in perspective. There are about 6 billion tons of carbon dioxide put into the atmosphere each year from all over the world. The United States is responsible for about 20 percent of that, about 1.2 billion tons. And about a third of that comes from transportation sources, predominantly automobiles. And that is what the amendment that Senator Wirth and I have written deals with.

The essential element of the amendment is that we have recognized that there is a continued increase in the number of automobiles, and that the vehicle miles traveled in this country continue to increase. They are up 27 percent over the last decade. It takes quite a while for cars to end up in the junk yard. The average life to retirement is quite considerable. And, therefore, to achieve any progress, or even a standstill, on the reduction of carbon dioxide from tailpipes, particularly over the next 10 years, we are going to have to increase fleet average fuel efficiency standards for new cars much, much faster than in the past and faster than the expected increase in vehicle miles traveled.

And that is why the amendment proposes significant and major increases in the CAFE standards which are now at 27.5 miles per gallon. Under our amendment these would increase by 20 percent by 1993, by 45 percent by 1997, and by 65 percent by the year 2000.

Now, you will notice that we have abandoned the annual ratcheting of CAFE standards. We do it in steps because informed discussion with the industry indicates that while none of these standards will be easy to achieve, they will be easier to achieve if we give them a plateau and then a step and then a plateau of several years for them to make their marketing and production decisions.

Thirdly, we have not created specific, across-the-board CAFE standards in miles per gallon for each step. We have defined them as percentage increases. And the reason for that is to avoid setting an unfair or unattainable standard. What we have chosen to do is eliminate the real inequity of compelling all manufacturers, regardless of where they are in the process, to meet fixed, absolute corporate average fuel economy standards every year.

Fourthly, we have recognized that the current penalty which is, in fact, a criminal penalty for noncompliance with the CAFE standards does not work. No one is going to put auto executives in jail or subject them to a felony count, or the board of directors to a criminal sanction, let alone prison or that kind of criminal penalty. And we have said there ought to be a tax for noncompliance, and our tax, which is \$5 times the number of a tenth of a percent per miles per gallon that is missed times the numbers of vehicles manufactured by that manufacturer that year, amounts to an extremely modest, in my judgment, economic rent, \$50, if you will, per vehicle if the manufacturer misses by an entire mile per gallon. While the tax is modest, nonetheless it should provide a significant economic incentive as measured against the corporate profit opportunity to bring about compliance.

Finally, we ratchet up the gas-guzzler about the same rate as we have over the last nine years. It started at 15.5 miles per gallon in 1980. It is frozen right now at 22.5. It really should have been higher. And we would take that up another nine miles per gallon to 31.5 miles per gallon in the year 2000.

And finally, and I think most significantly, in order to encourage new technology, Senator Wirth and I and our cosponsors propose a tax credit for automobiles that are substantially more fuel efficient than those produced on the average. That tax credit would go to the consumer. It would start as low as \$400 for vehicles that are 20 to 25 percent more efficient than the average vehicle, up to \$2,000 for vehicles that are 75 percent more efficient. We believe that that will be a major incentive for auto makers to innovate in really major ways, not just fool around at the edges.

Mr. Chairman, I want to conclude my remarks by indicating that this legislation in my judgment is absolutely essential so that when people like Dale Bumpers go to Brazil, as he is this weekend, he can not only talk turkey, but exhibit that this country does not view global warming as merely somebody else's problem that affects us, that we view it as a problem over which we exercise considerable responsibility and for which we must take action.

But whether one is a believer in global warming or not, whether one believes there is greenhouse effect or not, I would like to suggest that what we have proposed is good energy conservation policy on its face. We all remember—when I was a member of this committee and when I was a member of the House energy subcommittee—how everybody in 1973 said, my God, we are vulnerable to an oil cutoff in the Persian Gulf, and we were. In 1979 and 1980 and 1981, we were vulnerable to economic blackmail when per barrel energy costs got up into the high 20s. And so, a sound energy policy is one that will allow us to determine our own destiny, not have other people determine it for us.

And I would also suggest that our legislation is sound competitive policy. I suspect everybody in this room at one time or another has made a speech about the problem of our trade deficit. It used to be about \$170 billion a year, now down to maybe \$130 billion a year.

What it means is that other countries are piling up dollars just waiting to buy more and more of the United States with them. Over half the banks in Los Angeles are owned by foreign nationals, the Japanese particularly.

People complain about this country being bought up and sold out to foreign interests. We are only going to get control of that when we stop buying a lot of stuff we don't need to buy from abroad. And energy is something that if we conserve, we do not need to buy from abroad.

So, I submit, Mr. Chairman, that what Senator Wirth and I are proposing is not just good for planetary ecology, not just good energy policy, it is good competitive policy as well.

And I thank you, Mr. Chairman.

[The prepared statement of Senator Heinz follows:]

STATEMENT OF SENATOR JOHN HEINZ

Global Warming

MR. CHAIRMAN, I FIRST WANT TO COMMEND THE COMMITTEE AND ITS MEMBERS FOR MOVING SO QUICKLY TO CONSIDER S. 324, AND THE GREENHOUSE EFFECT IN GENERAL. GLOBAL CLIMATE CHANGE MAY TRANSFORM THE PLANET AS WE KNOW IT. MAN'S BURNING OF FUELS HAS DOUBLED THE CONCENTRATION OF CARBON DIOXIDE IN THE ATMOSPHERE SINCE THE START OF THE INDUSTRIAL REVOLUTION. A DOUBLING OF TODAY'S CONCENTRATION MAY OCCUR IN THE NEXT 50 YEARS. THERE IS EVIDENCE THAT BY THE MIDDLE OF THE NEXT CENTURY, TEMPERATURES MAY RISE IN THE RANGE OF 5 TO 10 DEGREES FARENHEIT, AN INCREASE OVER 60 YEARS EQUIVALENT TO ALL THE WARMING WHICH HAS TAKEN PLACE SINCE THE LAST ICE AGE, 18,000 YEARS AGO.

THE SPEED OF GLOBAL CHANGE WOULD OUTSTRIP THE ABILITY OF MANY NATURAL ECOSYSTEMS TO ADJUST, CAUSING WIDESPREAD LOSS OF FORESTS AND WILDLIFE. RISING SEA LEVELS WOULD INUNDATE COASTS AND CAUSE WIDESPREAD FLOODING. RADICALLY CHANGED AND DIMINISHED RAINFALL PATTERNS WILL TURN PRODUCTIVE FARMLAND INTO ARID DUST-BOWLS. IN SHORT, LITTLE OTHER THAN WORLD WAR WOULD CAUSE MORE DISRUPTION TO THE GLOBAL ENVIRONMENT.

S. 324, THE LEGISLATION WHICH SENATOR WIRTH AND I, AMONG OTHERS, HAVE SPONSORED TAKES A COMMON SENSE APPROACH -- NAMELY, IMPROVING

ENERGY EFFICIENCY -- TO ATTACKING THE UNDERLYING CAUSES OF GLOBAL WARMING.

ENERGY EFFICIENCY IMPROVEMENTS IN THE TOTAL ECONOMY HAVE BEEN FLAT FOR TWO YEARS, AFTER 13 YEARS OF PROGRESS. THIS IS A VERY DANGEROUS TREND, MR. CHAIRMAN, BECAUSE IF THE ECONOMY GROWS BY ONLY 2 PERCENT A YEAR OVER THE NEXT 12 YEARS IT WILL TAKE A 21 PERCENT REDUCTION IN THE ECONOMY'S ENERGY INTENSITY TO KEEP CO2 EMISSIONS AT THEIR 1988 LEVELS. MOST OF THE BILL'S PROVISIONS SHOULD BE ENACTED REGARDLESS OF THE GREENHOUSE EFFECT; THEY ARE SOUND ENERGY POLICY.

THE BILL BEFORE THE COMMITTEE IMPROVES ENERGY EFFICIENCY IN MANY WAYS. IT ESTABLISHES INDUSTRIAL RESEARCH CENTERS, AND NEW RESEARCH EFFORTS; IT ALTERS UTILITY REGULATION IN ORDER TO EMPHASIZE CONSERVATION, ESTABLISHES EFFICIENCY STANDARDS FOR LAMPS, HOME ENERGY RATING SYSTEMS, AND MORE.

AT THE END OF LAST YEAR, TIM WIRTH AND I RELEASED PROJECT 88, AN INNOVATIVE REPORT WHICH RECOMMENDED A SERIES OF MARKET INCENTIVES TO COMBAT GLOBAL WARMING, AIR POLLUTION, ACID RAIN, TOXIC WASTE, AND MORE. THE REPORT'S 36 RECOMMENDATIONS SUPPORT MARKET-ORIENTED INCENTIVES TO SUPPLEMENT AND EXPAND REGULATORY PROGRAMS.

S. 324, AND THE AMENDMENT WHICH SENATOR WIRTH AND I HAVE INTRODUCED TO SUPPLEMENT THE BILL, BUILD ON THE RECOMMENDATIONS

OF PROJECT 88, AND WILL PROVIDE LEAST COST SOLUTIONS TO THIS MOST SERIOUS PROBLEM.

THERE ARE FOUR PRIMARY SOURCES OF CO2 EMISSIONS IN THE ATMOSPHERE. ELECTRIC UTILITIES MAKE UP 33 PERCENT OF THESE EMISSIONS; TRANSPORTATION MAKES UP 31 PERCENT, AND INDUSTRIAL AND RESIDENTIAL EMISSIONS MAKE UP 34 PERCENT.

IN ORDER TO ENSURE THAT TRANSPORTATION, NEARLY A THIRD OF THE PROBLEM, RECEIVES THE ATTENTION IT NEEDS, SENATOR WIRTH AND I INTRODUCED OUR AMENDMENT.

DUE TO INCREASED NUMBERS OF CARS, AND VEHICLE MILES TRAVELED, FUEL USE AND CO2 EMISSIONS ARE INCREASING IN THIS NATION. TO REDUCE CO2 EMISSIONS, WE MUST INCREASE EFFICIENCY FASTER THAN VEHICLE MILES TRAVELED, EVEN RECOGNIZING THAT FLEET AVERAGE EFFICIENCY IS SLOWLY INCREASING AS OLD CARS ARE RETIRED.

SINCE YOU WILL HEAR A GREAT A DEAL ABOUT S. 324'S PROVISIONS FROM YOUR OTHER WITNESSES, I WANT TO FOCUS ON THE AMENDMENT, WHICH IS BASED ON THE PREMISE THAT FEDERAL INCENTIVES MUST BE APPLIED TO RAPIDLY INCREASE THE EFFICIENCY OF THE TRANSPORTATION SECTOR, PARTICULARLY AUTOMOBILES.

OUR AMENDMENT ELIMINATES THE REAL WORLD INEQUITY OF COMPELLING ALL MANUFACTURERS TO MEET FIXED, ABSOLUTE CORPORATE AVERAGE FUEL ECONOMY STANDARDS EVERY YEAR. INSTEAD, WE WOULD REQUIRE ALL

MANUFACTURERS TO IMPROVE THEIR EFFICIENCY BY A PERCENTAGE LEVEL, PHASED IN OVER TIME. BY REQUIRING EACH MANUFACTURER TO INCREASE FROM ITS BASE, THERE WILL BE CONTINUING IMPROVEMENTS FROM ALL MANUFACTURERS. OVERALL EFFICIENCY LEVELS WOULD BE INCREASED TO 65 PERCENT ABOVE PRESENT LEVELS BY THE YEAR 2000.

PHASING IN THE INCREASED EFFICIENCY STANDARDS GIVES MANUFACTURERS TIME TO RETOOL IN ORDER TO MEET THE HIGHER STANDARD.

THE PENALTY FOR FAILURE TO COMPLY WITH CAFE STANDARDS HAS BROUGHT ABOUT COMPLAINTS FROM MANUFACTURERS AND HAS NOT OPERATED AS AN INCENTIVE. WE WOULD CHANGE THE PENALTY BY IMPOSING A TAX ON MANUFACTURERS WHO FAIL TO COMPLY WITH THE LAW.

THE EFFICIENCY INCENTIVES PROVIDED BY THE GAS-GUZZLER TAX HAVE ALSO LOST THEIR EFFECTIVENESS. FROM 1980 TO 1986 THE CUT OFF POINT FOR THE TAX INCREASED FROM 15 MILES PER GALLON TO 22 MILES PER GALLON, BUT HAS BEEN UNCHANGED FOR THE LAST 3 YEARS. OUR AMENDMENT INCREASES THE CUT OFF POINT IN INCREMENTS, RISING FROM THE PRESENT LEVEL TO 31.5 MILES PER GALLON IN THE YEAR 2000. THIS INCREASE IS CONSISTENT WITH THE INCREASES APPLIED SINCE THE TAX WAS ENACTED. MOREOVER, THE INCREASES WILL ALLOW THE GAS GUZZLER TAX TO OPERATE IN TANDEM WITH THE CORPORATE AVERAGE FUEL ECONOMY STANDARDS, MAXIMIZING ALL POSSIBLE INCENTIVES.

FINALLY, THE MEASURE PROVIDES A TAX CREDIT FOR CONSUMERS WHO PURCHASE MORE EFFICIENT CARS, STARTING IN 1993. THE AMOUNT OF

CREDIT IS BASED ON A SLIDING SCALE DEPENDING ON HOW MUCH MORE EFFICIENT THE VEHICLE IS THAN THE AVERAGE CAR IN ITS CLASS. THE CREDIT AMOUNT VARIES FROM \$400 FOR CARS THAT ARE 20 TO 25 PERCENT MORE EFFICIENT THAN THE AVERAGE, TO \$2000 FOR CARS WHICH ARE 75 PERCENT MORE EFFICIENT. IN SHORT, CONSUMERS WOULD GET A BREAK FOR DOING THE RIGHT THING.

THE ADVANTAGES OF THE AMENDMENT ARE THUS TWO FOLD: FIRST, DEMAND FOR MORE EFFICIENT CARS WOULD BE STIMULATED THROUGH THE TAX CREDIT FOR EFFICIENT VEHICLES; SECOND, THE GAS-GUZZLER TAX AND THE CORPORATE AVERAGE FUEL ECONOMY STANDARD WOULD WORK TOGETHER TO DISCOURAGE INEFFICIENT VEHICLES. THE END RESULT, SENATOR WIRTH, WOULD BE TO REDUCE THE NUMBER OF SAPLINGS REQUIRED BY EACH NEWBORN CHILD IN ORDER TO OFF-SET HIS OR HER LIFETIME CO2 EMISSIONS FROM 300 TO 250.

I RECOMMEND THE AMENDMENT TO YOU, AND URGE THE COMMITTEE TO INCLUDE IT IN FULL AS PART OF S. 324, WHICH I HOPE YOU WILL REPORT FAVORABLY TO THE SENATE.

THANK YOU, MR. CHAIRMAN.

The CHAIRMAN. Thank you very much, Senator Heinz, for a very thoughtful statement.

Now we would like to welcome back to the committee a former member, a constructive member, and I am glad to have his constructive comments back here. Senator Fowler?

STATEMENT OF HON. WYCHE FOWLER, JR., U.S. SENATOR FROM
GEORGIA

Senator FOWLER. Mr. Chairman, thank you very much. And to my former colleagues. I miss you. I was forced by the arcane and obtuse rules of this body to relinquish my seat, which I did kicking and screaming. You were kind to allow me to come back. I know you have a big schedule today of very competent people. So, I will try to be uncharacteristically brief.

Senator HEINZ. Mr. Chairman, could I ask the committee that I might be excused to another hearing unless you want me to hang around? I would be happy to if you want me to.

Senator BUMPERS. Could I ask him one question before he leaves?

The CHAIRMAN. Yes.

Senator BUMPERS. Senator Heinz, you have a tax credit involved in your amendment, up to \$2,000 for a very efficient automobile. Have you had a cost analysis done on that?

Senator HEINZ. No, I haven't Mr. Chairman. But obviously it is going to cost money, probably as much as the capital gains proposal the President has made that I am supposed to be in a hearing on right now.

Senator BUMPERS. Well, I am not for that. [Laughter.]

I may be for yours.

Senator HEINZ. Maybe we can work a trade.

Senator BUMPERS. Fine.

The CHAIRMAN. Senator Heinz, let me ask you one question before you get away. You would have each manufacturer improve by 65 percent. Now, as I look at these existing standards, BMW, for example, is only at 24.9 miles per gallon. They just pay the fine, whereas Isuzu is at 38.8. Now, if you made both of those improve by 65 percent, a 65 percent increase for Isuzu would be a tremendous number, whereas it would be not too great a number for BMW, which seems to tend to reward those who have violated the law in the past.

Senator HEINZ. And we run into the same problem if we have a specific annual rate that applies to everybody. I am not saying there may not be a way of splitting the difference, but I do think that the present system is unrealistic.

Yes, we do ask those people who have shown the technological and marketing and production ability to do better—to do, indeed, more, but it is the same percentage improvement. But there may be ways of addressing that, but I don't think the present system that we have had where everybody, regardless of where they are today, has to meet 27.5 or 30.5 or 55.5 is right either.

The CHAIRMAN. One more question. This fine approach seems to work with American manufacturers because they tend to obey the law if for no other reason because think they might subject themselves to corporate derivative suits, stockholder derivative suits,

whereas the foreign manufacturers are not worried about that and so they just pay the fine. What is your response to that problem?

Senator HEINZ. I think the fine is a more appropriate mechanism—excuse me—what I will call the penalty tax, as opposed to a criminal fine or penalty, is a better way of achieving compliance. It is not subject to the kind of lengthy court battle that a criminal prosecution would entail. It may very well be that the \$5 per one-tenth of a mile failure is too low. I said in my comments it is a very modest economic rent. It may be too modest, but I do not have currently the information or capability to do a better analysis. I do think a better analysis is needed.

The CHAIRMAN. Thank you very much, Senator Heinz. Senator Fowler?

Senator FOWLER. Mr. Chairman, thank you for giving me this opportunity to say a few quick words about the Energy Efficiency and Renewable Energy Technology Competitiveness Act, which I wrote, but I can assure you I did not title. And if you pass it again, it will go down to a one-word title.

It was introduced again in this Congress by Senator Murkowski and myself. As you will recall, we passed it with strong bipartisan support twice in the Senate last year, and then lost it. It bogged down in budget negotiations with the House.

The bill, Mr. Chairman, calls for stronger efforts in research, development, demonstration and commercialization of energy efficiency and renewables, specifically solar, photovoltaics, biomass, wind, among others.

We had, as you know, very productive conservation programs on a sustainable path of development which held great promise for alternative energy technologies developed under both Democratic and Republican administrations. But in the last 10 years, those efforts and funding have been cut by four-fifths at a time when all of us, for the reasons discussed this morning, are crying out for a comprehensive energy policy that goes beyond a sole reliance on the fossil fuels. The further reductions proposed by the new administration would seriously, I'm afraid, continue that downward path.

We know how to harness energy from clean and virtually inexhaustible renewables. These products are beginning to prove they can compete in the market. We need to concentrate our efforts to bring these technologies into the mainstream and to make them a major force in meeting our future energy needs.

Mr. Chairman, if I may, I would like to submit my full statement for the record. I won't give you the full speech because you know it.

We need a comprehensive energy policy. We have it within our grasp. Taxpayers' dollars over the last 20 years have already proven through Federal tax research how to do all of these alternative energy strategies. If we just put a little money in to solve some of the commercialization problems, we could go light-years ahead in our international competitiveness, our self-sustainability in energy here, and to have the right mix with the fossil fuels to have a comprehensive energy policy that can lead in our efforts with the world problems that we have been talking about this morning.

I am sorry Senator Bumpers had to leave, but I do want to make one comment before he goes off to Brazil, and maybe his staff and those going with him will take this message to President Sarney.

Unfortunately, in our international efforts, we do have the reputation in this country because we do not do the job that easily can be done at extraordinarily low cost—we have the reputation in the international community of presenting every public problem as if it were an opportunity for private profit. And unless we do what we must do and can do in this country, it is very difficult to put together the kind of international strategy and cooperation that must be done, as all of you know, if we are going to solve some of these health issues that mask under the title of environmental, but they are extraordinary health issues for everybody that lives on this planet.

President Sarney has to understand, but he can't understand if it looks like we are trying to snatch it out from under him, that Amazonia—those forests are the lungs of our planet. They are the lungs of the universal body. If those forests go, then we have serious problems, to understate the case.

But we cannot expect him to give up his forests when—I just came back from forestry hearings in Georgia yesterday—our cuttings are exceeding 35 percent of plantings in this country. And that is under the private forestry system. Part of that is what we did in the tax code two years ago by removing the capital gains treatment and passive loss on forestry that had been put in in 1940 as a conservation measure.

But when we do what we can do here to show, as several people commented in their testimony—and I certainly agree—that we are taking the lead because we have developed a comprehensive strategy, then we have a much better chance of convincing our friends.

This is a modest first step, Mr. Chairman. I am very pleased that the cosponsorship by my friend, Frank Murkowski from Alaska, and the others—if we could pass this quickly. This is in your bill, Senator Wirth's bill, the overall major bill. But we are on a dual track. We have also introduced it separately as a separate bill. And if this committee, as it did last year, could quickly pass this and endorse the renewables and conservation section, I think it would not only help us immediately with the House in getting the key piece of the big bill, it would give us a leg up in a more comprehensive approach, which my friend from Colorado has taken the lead on.

Thank you very much.

[The prepared statement of Senator Fowler follows:]

Global Warming Hearing
Senate Energy Committee
March 14, 1989
Senator Wyche Fowler, Jr.

I am here to testify about the Renewable Energy and Energy Efficiency Technology Competitiveness Act, which I recently introduced, and which is also incorporated in the the National Energy Policy Act of 1989.

My bill calls for stronger efforts in research, development, demonstration and commercialization of energy efficiency and renewables: solar, photovoltaics, geothermal, wind, biomass. We had very productive conservation programs, promising alternative energy technologies, developed under both Republican and Democratic administrations, which have been reduced in the last eight years to borderline status. The further reductions proposed by this administration would seriously compromise their effectiveness in advancing these technologies. We know how to harness energy from clean and virtually inexhaustible renewables. These products are beginning to prove they can compete in the market. We need to concentrate our efforts to bring these technologies into the mainstream and make them a major force in meeting our future energy needs.

I first introduced this legislation in the 100th Congress, as a member of the Senate Committee on Energy and Natural Resources, because we need a comprehensive energy policy as the foundation of a strong economy. That policy must yield greater self-sufficiency in meeting

our energy needs, and the resources that produce renewable energy cannot be controlled by any foreign power.

I also believe that the incorporation of renewables into our energy policy is important for international competitiveness. As we have relaxed our efforts, other countries have seen the opportunities offered by renewables and have expanded their own research programs. Countries like Japan and Germany are now poised to surpass us in technologies we such as photovoltaics which we invented.

But one of the most important benefits of these developing technologies, that we cannot afford to overlook, is their environmental promise. In particular, they do not generate the emissions behind the greatest environmental threat we face today: global warming.

Energy policy is inextricable from environmental policy. They have to be closely coordinated. We have the means to do it, but this is not reflected in our policies. The most glaring example of counterproductive government action is the relaxing of gas milage standards -- which increases fuel consumption and emissions.

Renewables can play a strong role in a more beneficial symbiosis of energy and environmental policy. Solar thermal technology can match peak production with peak demand -- without polluting emissions. Some biomass techniques can actually subtract carbon from the atmosphere.

We can and must do a better job of capitalizing on these opportunities. Even as the scientific evidence of global warming caused by fossil fuel emissions has grown more conclusive, US funding for research in energy efficiency and clean renewables was cut by four-fifths during the last administration. I want to stop this trend. I think the US must show the way in developing energy technologies that are safe, dependable, and do not exact large scale ecological damage -- through resource extraction or polluting emissions.

I say we should lead for two reasons. We still have the strongest scientific capabilities of any nation, in spite of continuous budget cuts. We are also the world's largest producer of greenhouse gases. The combustion of fossil fuels in this country alone accounts for 25 percent of the world's carbon emissions.

The renewables bill I propose passed the Senate twice in the 100th Congress, but stalled in budget negotiations with the House. I hope we will be able to move forward with this legislation in this session of Congress. Renewables are now only capable of meeting part of our energy needs, but the technologies are progressing and can be improved further. We are now using only a fraction of their potential. It would be a mistake to say that because investments in renewables will not provide an immediate return, that we will not prepare the way for their widespread use in the long run.

These things make good energy sense and good environmental sense, and we should vigorously pursue them.

Our buildings consume 35 percent of our energy and produce more greenhouse gases than the utility sector. Yet we do not give serious support to solar buildings research that could address both these issues.

The development of renewables technology can also have strong implications beyond our borders. By exporting these products, we can improve our trade balances. We can, at the same time, reduce the need for Third World power projects that contribute to the greenhouse effect -- both through emissions and deforestation. Photovoltaics can be used effectively to generate electricity in remote locations that are not connected to a power grid.

Once they are developed, the capital and environmental costs of establishing these systems are almost nothing compared to traditional those of traditional energy technologies. Solar systems can easily be integrated into the existing utility sector, here and abroad, increasing power supplies without increasing pollution. Photovoltaics and solar systems can also prove much more economical than conventional energy sources, in that capacity can quickly and easily be expanded in increments that match demand. These are some of the reasons we already see solar plants generating power for an industrial park in Shenandoah, Georgia, and meeting peak load in Los Angeles, California.

Development of renewables is important to meet our energy needs and to remain competitive internationally. At the same time, these technologies, along with increased energy efficiency, can greatly reduce industrial, residential and utility emissions that contribute to the greenhouse effect. That makes them a potent weapon against catastrophic climate change.

Renewable energy and energy efficiency should be an important part of any national energy policy established to reduce global warming.



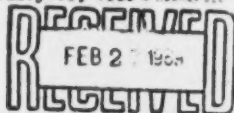
OFFICIAL COMMITTEE FILE
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Alaska Natural Gas Transportation System

FA-1
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SENATE COMMITTEE ON
ENERGY AND NATURAL RESOURCES
February 10, 1989

D-0025437

Honorable Dan Quayle
President of the Senate
Washington, D. C. 20510



Dear Mr. President:

WASHINGTON DC 20510

This report is submitted pursuant to the Alaska Natural Gas Transportation Act of 1976 (P.L. 94-586) (ANGTA), which requires the Federal Inspector to submit reports to the Congress on the status of the Alaska Natural Gas Transportation System (ANGTS). This report covers a longer period of time to coincide with my departure as Federal Inspector and represents the Office of the Federal Inspector's (OFI) thirty-first report, summarizing significant project developments that occurred from July 1988, through February 1989.

ANGTS System Flow

The Alaska Natural Gas Transportation System (ANGTS) was designed to bring Alaskan natural gas from Prudhoe Bay on Alaska's North Slope, south across western Canada, to U. S. markets in California and the Midwest. The first phase of the 4,800-mile natural gas pipeline, the prebuild segments, comprising 32 percent of the total System and 1,512 miles, was completed in 1982, and Canadian gas now flows through the Western Leg to Stanfield, Oregon, and the Eastern Leg to Ventura, Iowa. Because of changing energy market conditions, the sponsors of ANGTS decided in 1982, to postpone construction of the Alaskan segment of the System.

During the last two quarters of 1988, the prebuild segments of the ANGTS continued to transport record volumes of natural gas. Both the Western and Eastern Legs continued to run at about full capacity throughout the six-month period.

In addition, the Pacific Gas Transmission Company (PGT), the Western Leg sponsor, filed application with the Federal Energy Regulatory Commission (FERC) in December 1988, to complete the Western Leg of ANGTS. As of now, PGT has not requested treatment under the provisions of ANGTA. The proposed Expansion Project would allow approximately 710 MMcf/d of natural gas to be received at Kingsgate, British Columbia, and, on an average annual basis, approximately 150 MMcf/d to be delivered to the existing interconnection with Northwest Pipeline Corporation at Stanfield, Oregon, and approximately 600 MMcf/d to be delivered to the existing interconnection with Pacific Gas & Electric (PG&E) near Malin, Oregon.

The proposed Expansion Project also includes looping of the PG&E intra-state pipelines within the State of California. PGT representatives met with this Office during the last quarter of 1988 to advise us of their plans.

Alaska Segment Activity

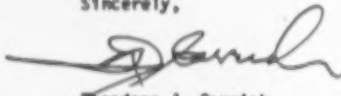
In November 1988, the Bureau of Land Management issued a Right-of-Way Grant for the Trans-Alaska Gas System (TAGS). This proposed competing gas pipeline would transport North Slope natural gas to Valdez in Southern Alaska where it would be prepared for export to countries on the Asian Pacific Rim.

In a connected action, the TAGS sponsors have requested the Department of Energy (DOE) issue an authorization under the Natural Gas Act to export North Slope natural gas to the Pacific Rim. In January 1989, DOE held a public conference in Anchorage to consider various issues raised by this request. Because of the Federal Inspector's responsibilities, the Deputy Federal Inspector attended this meeting.

Conclusion

During my tenure as Federal Inspector I believe there have been positive signs of progress towards the efficient development of our vast natural gas resources in Alaska. The Federal Government has completed its responsibilities to remove Governmental impediments to the construction of ANGTS and the OFI has remained ready to assist the sponsors begin work on the remainder of the System. The ANGTS sponsors continue to reaffirm their commitment to the completion of the project and I am confident that work will begin soon so that my successor will be able to carry out the role of the OFI to expedite and oversee the completion of this essential energy project.

Sincerely,



Theodore J. Garrish
Federal Inspector



The CHAIRMAN. Thank you very much, Senator Fowler.

I might add that Secretary Watkins has promised a comprehensive energy policy of which I hope this field, this area, if not this precise bill, will be a part and will help us get it passed all the way through the process.

Senator FOWLER. Thank you, sir.

The CHAIRMAN. Do you have time for questions?

Senator FOWLER. Sure.

The CHAIRMAN. Does anyone want to ask questions?

Senator MCCLURE. Well, I will be very brief, Mr. Chairman. I am very pleased that you mentioned a couple of things that we have done that are counterproductive like the removal of the capital gains treatment on forestry. I agree with the statement that you made. That was a step in the wrong direction. It is producing the wrong results. But it was done under the mistaken apprehension on the part of some people that that was an undue subsidy to an industry.

Similarly, I know there will be vigorous dissent and vigorous debate over the question of how that relates to forestry management in the United States. But I think we do know that over-age, mature forests in which the trees are dying contribute to CO₂ emissions rather than fixing carbon in the atmosphere. And one of the obvious answers, if global warming is the threat, is to replace such forests with vigorously growing young forests.

In the last two or three years, we have seen budgetary constraints, and we seem always to get back to the question of where do we get the money. We have seen budgetary constraints force us to reduce the application of the KV funds in forestry management, and it has been used up in fighting forest fires because we haven't been able to get the appropriations to pay the forest fire suppression costs.

We have had a good reforestation program on the Nation's national forests—good on paper, not good in practice because it is not sufficient. And that is bad environmental policy, and it is bad economic policy. And we have to find ways to do that. But, again, we get back to the budgetary question.

And so, many of the things we look at are desirable to do, but we either then have to find areas within the budget in which to save money or increase taxes or confess that we are going to increase the Federal budget deficit. We increased the Social Security taxes dramatically in order to make sure that that fund was solvent and the money would be there at the time the baby boomers get to retirement age, and now we are robbing the fund to spend for current spending all across the board throughout the budget.

But we do get back to budgetary constraints, and I guess that's a way of saying we certainly have to find ways to address the problems that are presented in this bill. And I commend you and others for bringing these issues forward, but we also have other problems that are somehow connected to and interrelated and sometimes contrary to what we are attempting to do here.

I know that you will continue to do, as you have in the past, try to find the balances between those questions. But if global warming is the thing that is forcing us to take another and closer and stronger look—and I tend to believe that that is really why we are

paying more attention now than we were—then, it seems to me, that it is saying that has a priority over some other concerns.

Senator FOWLER. I would say to my friend—and I appreciate it—that we all know that we are subject to the penny-wise and pound-foolish decisions. In the case of renewables, we subsidize through our tax dollars the development. Just take solar photovoltaics, which the taxpayers of the United States basically paid for in its development. Now the Japanese in two years, because we stopped when we could have captured the whole market—we just gave it to the Japanese. And they have 85 percent—and that share is growing—of a worldwide market with multi, multi billion dollars in potential, especially in the third world, all these countries where you don't have and don't need a power grid.

When you look at the overall problem of our twin budgets, deficits, trade, nothing, no field has greater potential for American competitive, capitalistic leadership than the development of alternative energies, which we already know how to do. All we have to do is get the demonstration models out there so the private sector can take off.

And what it would do for a comprehensive energy policy—it complicates everything, including dictating where we send our men and boys in the armed forces now—I don't believe there is an individual here who would think for a second that we would have been in the Persian Gulf with our fleet if we weren't dependent upon imported oil. So, everything of a national security dimension that we pay billions and billions of dollars for is complicated by the fact that we are solely reliant on basically one source of energy, when we already know how to do the others.

And when we want to put together international business to try to come up with a way to—whether it be save the planet or redress our trade imbalance, we continue to cut off our nose to spite our face because of our inaction on what we already know how to do.

Senator McCLURE. Let me make a suggestion on renewables. We will just rename the program and call it a synthetic fuels program and create a new corporation.

Senator FOWLER. Brother McClure, all I can tell you is that I will accept any name except what is on it now.

Senator McCLURE. Thank you very much.

The CHAIRMAN. Further comments? Senator Wirth?

Senator WIRTH. I just want to thank Senator Fowler. His legislation and Senator Murkowski's legislation is built into the bill we are having a hearing on today. And, Wyche, we really appreciate your great help on this.

And the point that has been brought up is absolutely imperative, and that is that almost everything that we are going to do in terms of renewables and solar and efficiency, almost everything that is in this legislation is good economics. And looking at energy efficiency is good for the country in every way. I mean, there can be no question about that.

Solar has met every standard we have asked it to meet, and it is potentially very good for the United States economy.

Automobiles. You know, if we do the kinds of things that Senator Heinz was suggesting, that is going to be very good economics for the country and for the auto industry.

Timber. If we look at the subsidies that Senator McClure has described accurately—and we have to understand what the direct subsidies are and the indirect subsidies are—and I think we will find that that is very good for the economy.

Utility regulation, changing the ways in which we are regulating utilities so the utilities are allowed to build conservation into their rate base is very good economics.

So, we are going to see that over and over and over again, and I hope as we deliberate on your bill and this overall omnibus bill, that we keep good economics as one of the standards because if we do, that is going to drive the more rapid passage of the legislation.

Thank you again for all your help. We miss you on the committee and welcome you back.

Senator FOWLER. Mr. Chairman, I thank you for your courtesies and all of you for your attention.

Senator MURKOWSKI. Mr. Chairman?

The CHAIRMAN. Yes, Senator Murkowski?

Senator MURKOWSKI. I commend my friend, Senator Fowler, for his presentation, and particularly the emphasis on the renewable energy technology. I think it represents a fair balance. And that is what is going to have to occur as we address the continued concern that we have.

Mr. Chairman, I would ask that an article from the Christian Science Monitor of March 14 by Senator Wirth and myself concerning the Tongass issue be entered into the record today because, as the Senator from Colorado is well aware, I don't think the Tongass issue belongs in the global warming bill. Realistically we have two-thirds of that forest set aside in perpetuity to stay in its natural state with one-third remaining on a perpetual yield basis.

And unlike the Brazil situation, the clear cutting down in Alaska is not being used in the sense of putting the land into agriculture. What we do is on a perpetual yield basis, plant more trees and in reality it becomes a sump and assimilates the carbon dioxide. And I just wanted to make sure that the record reflected the realization as to what a continued healthy, young forest does to assimilate carbon dioxide as opposed to an old-growth forest which has less assimilation. But in any event, we think in the Tongass we have the best of both worlds.

Thank you, Mr. Chairman. I would ask that that be entered into the record.

The CHAIRMAN. Without objection.

[The article referred to follows:]

THE TONGASS NATIONAL FOREST—AT RISK?

NO: DON'T CONFUSE IT WITH AMAZON BLIGHT

(By Frank H. Murkowski)

There are myths about Alaska that are entertaining: like the stories of mosquitos larger than crows (they're not), or temperature so cold a tossed glass of water will freeze before it hits ground (it won't). There are other myths about my state that are more serious because they can affect public policy decisions that in turn have a negative impact on the livelihood of thousands of Alaska residents. The timber industry in Alaska's Tongass National forest is one such case.

A new myth has it that timber harvesting in the Tongass is contributing to the world's global warming problems. This one is also untrue. In fact, the magnificent tree regeneration in the Tongass and our practice of "sustained yield" forestry (whereby a forest is never cut at a rate which exceeds its ability to regenerate itself)

are part of the answer to the problems of deforestation and "global warming," not the cause.

Under a sustained-yield management plan, 90 percent of the Tongass is set aside as wilderness and for other non-timber uses. Only 10 percent will be logged over the next 100 years. And in the harvest area, 48 trees grow back for every tree removed.

Harvesting trees on a continuing sustained-yield basis helps to reduce levels of carbon dioxide in our atmosphere. More Tongass trees die each year of old age than are cut down. Replacing some of the old and dying forest with young, vigorously growing forest increases the amount of carbon dioxide removed from the atmosphere. This is in sharp contrast to methods being used in the tropics, where trees are cut and burned, and the land is converted to farming.

Important legislation introduced by Sen. Timothy Wirth would address the global warming issue, but it also includes a section addressing timber management in the Tongass. Some of my colleagues recently traveled to Brazil and saw examples of tragic deforestation; they suppose that similar deforestation is occurring in the Tongass. Nothing could be further from the truth.

In the tropics, burgeoning populations and inequitable land distribution, combined with expanding agricultural exports, have made crop land for subsistence farming scarce. Thus virgin forests are cleared to grow food. Poor tropical soils result in nearly continuous tree cropping and forest clearing, with the degraded land left behind unable to support new forest growth.

I hate to see the very serious tropical deforestation problem trivialized by those who would use it to influence domestic policy debates over America's national forests. Rather than attacking sustained-yield forest practices in our national forest system—a system conceived by Teddy Roosevelt and Clifford Pinchot to combat rampant deforestation in the United States during the 19th century—we should be holding our national forests and our sustained-yield practices out as an example to other nations.

For years, those who would end logging in the Tongass have zeroed-in on the federal money spent by the Forest Service to enhance timber production. The annual funding was part of a congressional compromise reached in 1980 that set aside one-third of the forest (5.5 million acres—an area larger than the state of Massachusetts) as wilderness. The other half of that compromise provided funding of at least \$40 million annually for timber management to ensure a viable timber industry in southeast Alaska would remain; an industry upon which 4,500 jobs and one-third of the regional economy depends.

This year, in recognition of substantially improved timber markets, I introduced legislation to eliminate the automatic \$40 million funding for the Tongass. Were the opponents of timber harvesting satisfied? No! They have simply found a new reason to justify their cause—global warming. As far as the Tongass is concerned, it is a reason based on myth rather than fact.

YES: THANKS TO WASHINGTON'S BARGAIN-BASEMENT TIMBER SALES

(By Timothy E. Wirth)

On Prince of Wales Island, one of countless splinters of land that form the sprawling, remote archipelago of southeast Alaska, the last great rain forest in North America is under attack. Swaths of clear-cut land—where Sitka spruce, cedars, and hemlocks as old as 500 years once towered in dense stands—are strewn with logging debris. Nearby streams are silted with soil from eroding lands, threatening salmon runs. Areas essential for the survival of grizzly bears, bald eagles, and deer are gone.

This destruction of the Tongass National Forest results from a policy that stresses logging at the expense of carefully managing an ecological treasure that is "still in the morning of creation," as the naturalist John Muir remarked over a century ago.

For taxpayers, the timber harvests are a big money loser, costing more than \$360 million in the last decade. And the federal government's single-minded devotion to getting timber out of the Tongass makes the United States seem duplicitous when we encourage Latin American countries to preserve equatorial rain forests that they say they need for economical development.

Federal law requires that the Tongass supply 4.5 billion board feet of timber each decade. No other national forest has such a legislated goal. This mandate produces far more than the market needs, resulting in timber sales at bargain prices. Worse, it means harvesting even when fish and wildlife are threatened.

Another part of the problem is 50-year contracts signed by the Forest Service with two pulp mills in the 1950s. On all other national forests, timber sales are put up

for bids. On the Tongass, the anachronistic contracts commit two-thirds of the timber offered for sale to the exclusive use of the two mills, without bidding. This monopoly drives down timber prices even further.

Congress has written a blank check to log the Tongass. More than \$40 million is automatically appropriated each year to help power the chain saws and cut access roads to nowhere. These funds bypass the annual congressional scrutiny required for all other federal expenditures.

This timber program endangers one of the most important resources in the nation, a place of "endless rhythm and beauty," as John Muir put it. The Tongass is refuge to more than 400 species of wildlife, fish, and shellfish, and harbors one of the greatest concentrations worldwide of bald eagles and grizzly bears. For southeast Alaska, fishing and tourism provide more than twice as many jobs as timber. The salmon industry, for example, pumped \$139 million into the region and provided nearly 4,000 full-time jobs in 1987. The streams of the Tongass are the spawning grounds for 85 percent of Alaska's commercial salmon harvests.

Congress must cancel the blank check and enact a sound management policy that carefully balances the demands and resources of the Tongass. Legislation I introduced recently in the Senate would repeal the timber quota of 4.5 billion board feet per decade. This is consistent with a recent recommendation of the investigative arm of Congress, the General Accounting Office.

The Forest Service would have to request money annually from Congress for its Tongass programs, just as it must for all other national forests. Further, the two pulp-mill contracts would be repealed; both mills would be free to bid on timber in competition with other companies.

Central in my bill are provisions directing the Forest Service to rewrite its management plan for the Tongass by reversing its timber-first bias and providing protection for salmon fisheries, tourism, recreation, and wildlife habitats. Until a balanced plan is completed, my legislation would impose moratorium on logging in 23 areas that cover more than 1.8 million acres and are of special importance to wildlife within the Tongass.

At a time when two of the greatest challenges facing our nation are environmental protection and federal deficit reduction, reforming the Tongass timber program would make a meaningful contribution toward both challengers. And perhaps Prince of Wales Island will come to be a Symbol for future generations.

The CHAIRMAN. Thank you very much, Senator Fowler. Come back more often.

Next we have a panel with Dr. Jack H. Gibbons, Director of the Office of Technology Assessment; Dr. Robert Williams from CEES, School of Engineering and Applied Sciences at Princeton; and Mr. Ralph Cavanagh, Senior Attorney for the Natural Resources Defense Council in San Francisco. They will be addressing energy efficiency and conservation. Dr. Gibbons is accompanied by Dr. Peter Blair who is the Program Manager for Energy and Minerals Program of OTA.

Gentlemen, welcome and let's lead off with Dr. Gibbons.

STATEMENT OF DR. JACK H. GIBBONS, DIRECTOR, OFFICE OF TECHNOLOGY ASSESSMENT, ACCOMPANIED BY DR. PETER BLAIR, PROGRAM MANAGER, ENERGY AND MATERIALS PROGRAM

Dr. GIBBONS. Thank you, Mr. Chairman. We appreciate the opportunity to appear before the committee this morning, and I would like to submit our rather lengthy testimony for the record and rather summarize its contents.

The CHAIRMAN. Yes, without objection. All statements of all witnesses will be placed in the record in full, and they may proceed either in summary or as they wish.

Dr. GIBBONS. Mr. Chairman, we know that lots of rich details are now available about the dynamics of energy and what you can do about energy supply and utilization, far more details than obtained

a decade ago. And I think we will hear a lot more about those details today.

But lest we get perhaps prematurely submerged in the details, I would prefer to focus just for a few minutes this morning on the broader context of evolving energy policy and how the global warming issues are fitting into that. I do this in part because I got swept up in energy back about 1970, and it has sort of been like a tar baby. I haven't been able to let it go since.

Obviously, energy environment is a dynamic process. In the early 1970s, we were concerned about vulnerability to interruption, about shortages, about price manipulation and about future availability of energy. As a result of these concerns, the strategic petroleum reserve relieved the problem of short-term security, albeit at a pretty fair price, but that issue essentially is resolved. The deregulation of energy price and the upward movement of prices had brought in then during the 1970s a diversification of supply, although the Mideast still, unfortunately, reigns there, and it also brought in a variety of improvements in the way we use energy simply reflecting those new prices and the complementary public policies that went along with it.

Part of the surprising news during the 1970s, of course, was the realization of the enormous potential of gas, both in terms of its supply and also in terms of its salubrious environmental consequences. And, indeed, there was an extraordinary response of increased efficiency to the increased price that exceeded almost all levels of hope and expectations even of the optimists. The flat demand that resulted, despite a 40 percent growth in GNP, is a striking example of the history of the 1970s and the early 1980s. And this result eliminated the earlier sense of urgency about such things as accelerated development of breeder reactors and of fusion energy.

Now, in the late 1970s and in the 1980s, oil prices broke in part because of a combination of a lack of demand growth and also of other factors. As a consequence of that price-breaking, the so-called new energy sources suffered, especially synthetic fuels and certain areas of solar energy. But efficiency continued to roll in despite falling energy prices. The first figure in my testimony after page 4 indicates this extraordinary momentum of efficiency rolling into our system driven by the events and the policies of the 1970s and new investments that are now being made to improve overall productivity of our Nation.

The flat to falling domestic oil production exacerbated our import bills now amounting to about a third of our balance of payments deficit, and that, unfortunately, could go higher.

Well, these early dynamics and policy moves reflected three principal concerns. One was national security concerns, the concentration of petroleum in the Mideast. A second was economic vulnerability, balance of trade issues, the least-cost paths, the routes to improve competitiveness in our world trade. And the third policy move was triggered by the traditional environmental concerns such as acid rain.

Now, of course, Senator Wirth, the greenhouse problems have loomed up convincingly and constitute the fourth rationale that to some extent simply underscores earlier actions, but also in a very

extraordinary way, changes some of our priorities that are going to need to be reflected in our national energy scene.

The greenhouse problems reemphasize the value of higher efficiency in both production and use and also reemphasize the imperative for research and development in non-fossil fuel energy sources.

It also dramatically changes the priority of previous interest in fossil fuels. And I indicate some of the problems of fossil fuels on figure 5 in my testimony for you.

Finally, it dramatically highlights the fact that any sensible national energy policy must be conceptualized and carried out in a global context. It is a new focus on the global context that the greenhouse issues bring so forcibly to bear.

Well, out of this, I would like to make three observations about the new situation.

First, fossil fuels have, indeed, been a godsend to mankind. They have been the opportunity for the extraordinary provision of goods and services that we now obtain in world. But now the other side of that coin, namely, environmental problems, appears to be worse than we thought. But we have not yet fully gauged the role of burning fossil fuels relative to other sources of greenhouse gases. And it is our belief that we need a lot better understanding as we go along in order to make the kind of midterm and interim corrections that are required as we move toward resolving greenhouse issues.

But despite this fact of some uncertainty, a prudent people will want to shift energy supply research and development emphasis to non-fossil sources, but not to the extent, of course, that we ignore the nearer term imperative of introducing higher efficiency of conversion of energy and to reduce emissions from our present energy supply systems.

There are a lot of very interesting technical opportunities in new energy sources, and I enumerate those on page 19 and 20 of my testimony.

But as long as the price of energy is low, Federal support, it seems to us, will have to be sustained. Also, we have to remember that long-time commitments are required to effect any significant changes both in energy supply and its utilization.

The second observation has to do with the demand side. On the side of efficiency, we do know that there are already lots of ways to greatly improve things, and we also know that more research can move us even further. The figures 2, 3 and 4 in my testimony following page 6 indicate these in several sectors of demand. But the extent to which these opportunities make sense depends sensitively on the price or the perceived value of energy.

Let me give you an example. The real price of gasoline today is less than the real price was in 1973 when it all began. The tax on gasoline today is about 13 percent—this is in the U.S.—versus about 33 percent in 1973. So, if we look at real price and the relative taxation on gasoline, we are far behind where we were in 1973.

Furthermore, since changes in energy efficiency are caused by changing capital stock, that is, automobiles, buildings, refrigerators, much time is required for those changes to roll into the system. The increasingly competitive marketplace is also triggering

a surge of investment in productivity, generally in productivity of American industry. And this automatically now carries along a lot of energy efficiency investments and improvements. If energy were fully priced, a lot more of this would happen, of course, as it has in other countries where the GNP to energy ratio now far exceeds our own.

The third observation has to do with the new greenhouse phenomenon which makes it much more obvious that energy is a global issue. The phenomenon provides a new idea of what we mean by community or global common cause. Effective action, we now understand, absolutely requires international cooperation, but despite that fact, it is up to the energy-intensive industrial nations to provide the kind of leadership and technical options that can make the future possible. Fossil fuel combustion, low efficiency of use, extraordinary population growth, deforestation, these are no longer just regional challenges, they are everyone's challenge wherever they occur around the planet.

In summary, Mr. Chairman, it is due to human ingenuity that humanity has grown in numbers and in economy that we now all affect the global environment. That same ingenuity has enabled us to take note of what is happening and what it portends for us. And that same ingenuity also provides technical options to forestall unwanted effects. What we now face is whether and how to do it. Because the effects are intrinsically external to the marketplace, little is likely to happen without policy intervention. The journey we believe is neither short nor without pain, but as you have pointed out so clearly, there are lots of sensible steps that we can begin with now without the pain.

Thank you, Mr. Chairman.

Senator WIRTH [presiding]. Thank you, Dr. Gibbons. I know you are accompanied by Dr. Blair. Do you have any comments that you wanted to make, Dr. Blair?

STATEMENT OF DR. PETER BLAIR, PROGRAM MANAGER, ENERGY AND MATERIALS PROGRAM, OTA

Dr. BLAIR. Perhaps I can just underscore one point that Dr. Gibbons made in the testimony that the motivation of energy policy has changed rather markedly over the last decade and a half. And, in particular, this kind of paradox of the lack of a sense of urgency about energy supply and prices—the short-term stability that we see right now offset by the longer term concerns that we have discussed already at length this morning—leads to perhaps an opportunity or an obligation to reexamine our priorities on RD&D, research, development and even demonstration.

I attended the solar energy meetings the other day where you offered some comments and used the metaphor of an insurance policy. And I think that it is important that we recognize that in marketing the insurance policy, that it needs to appeal to all of the factors that affect consumer decisions. So, for example, we will hear about many technologies today like low-emissivity windows or improved industrial process controls and energy efficiency. Right now in an environment of low energy prices, the motivation for buying many of these things may only be partly related to energy

efficiency concerns, but may be related to other concerns that are more compelling, at least right now.

So, getting many of these products on the road to commercialization requires that these low-emissivity windows be easy to install perhaps, reducing labor costs, as well as improving energy efficiency. So, the multiple benefits of—that is, spreading risk of the insurance policy is an important consideration, particularly right now.

[The prepared statement of Dr. Gibbons follows:]

TESTIMONY OF

DR. JOHN H. GIBBONS
DIRECTOR
OFFICE OF TECHNOLOGY ASSESSMENT

Accompanied by

DR. PETER D. BLAIR
PROGRAM MANAGER, ENERGY AND MATERIALS
OFFICE OF TECHNOLOGY ASSESSMENT

before

Senate Committee on Energy and Natural Resources

on

S. 324, The National Energy Policy Act of 1989

March 14, 1989

Mr. Chairman:

Thank you for the opportunity to share with your Committee some of the findings of OTA's past and on-going work on the potential role of energy efficiency and renewable energy technologies as they relate to S. 324, the "National Energy Policy Act of 1989." This testimony addresses the status of research and development for many such technologies, their potential role in the U.S. energy mix, their current and likely future commercial availability if current trends continue, and alternative strategies for accelerating the role of these technologies over the next several decades.

Over the last decade the policy environment within which energy supply and demand decisions are made has changed considerably. Most importantly, the sense of urgency about the short-term security of energy

supply is no longer the primary driving force behind such decisions. Instead, the desire to improve competitiveness of U.S. products in world markets and the increasing concern over environmental impacts of burning fossil fuels currently provide additional, and perhaps even more compelling motivation for developing and maintaining a diverse array of energy supplies, especially from domestic sources. This changed decision environment will have important impacts on the appropriate policy tools for capitalizing on the benefits of energy efficiency and renewable energy technologies.

The concern over growing evidence that greenhouse gas emissions from burning fossil fuels are principal contributors to global warming and its potential manifold impacts provides a new incentive for efforts to reduce the Nation's dependence on such fuels beyond the more frequently cited concerns over environment, economic strength and vulnerability, and national security. Nonetheless, the more traditional motivations for reducing fossil fuel use remain. Hence, the national security concern over where future world oil production is concentrated (e.g., the Middle East), the role of oil imports (Middle East imports are now over half of our total oil imports) in U.S. foreign trade balance (oil currently accounts for a third of our trade deficit), the need to innovate in industry to be more competitive in world markets, and, finally, the increasing concern over the environmental impact of burning fossil fuels in the context of both the shorter term acid rain problem for coal as well as the longer term global warming problem for all fossil fuels, all collectively serve to elevate the

Energy Efficiency and New Energy Technologies: J. Gibbons

importance of policy initiatives aimed at improving U.S. energy efficiency and alternative energy technologies in spite the current period of stable energy supplies and prices.

THE ROLE OF NEW ENERGY TECHNOLOGIES

A variety of new as well as commercially available energy supply and conservation technologies have the potential for reducing U.S. dependence on fossil fuels considerably, but at the current rate of development and adoption this reduction in fossil fuel use is likely to occur very slowly without policy intervention. As you requested, my testimony today focuses on the technological and economic potential of new conservation and renewable energy supply technology over the next several decades.

OTA has completed a number of major assessments related to the subject of this hearing, most notably New Electric Power Technologies: Problems and Prospects for the 1990's, which addressed the commercial potential over the next several decades of a range of new electric power technologies including renewables. Currently OTA is preparing a special report entitled Climate Change: Ozone and Global Warming which will address among many other issues the role of existing and new energy technologies in slowing global climate change. In addition, the on-going OTA assessment, Technological Risks and Opportunities for Future U.S. Energy Supply and

Demand, addresses this issue among many others in the context of long term energy policy.¹

Energy Efficiency

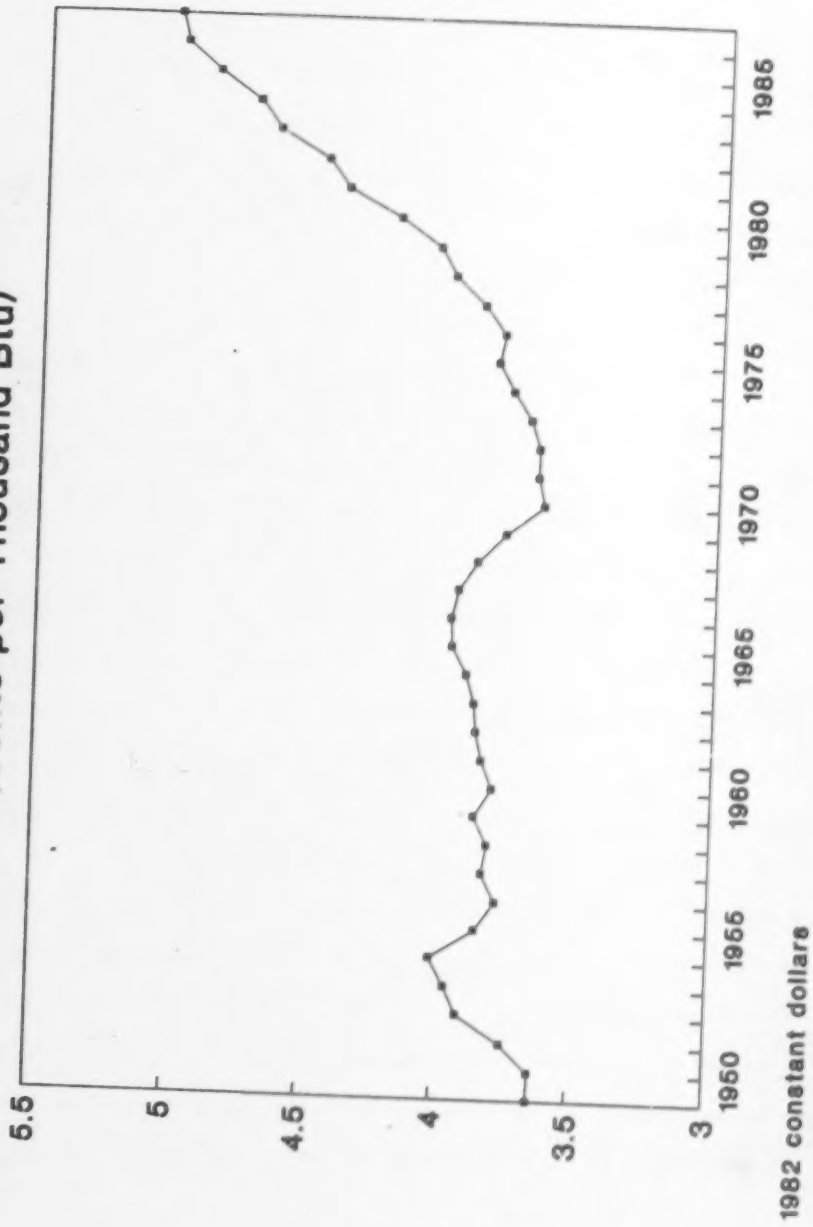
In retrospect, since the early 1970's, efforts to improve energy efficiency have been among the most successful components of U.S. energy policy. In many cases, investments in energy efficiency exceeded even the most optimistic forecasts, contributing substantially to the happy outcome of almost no increase in total energy consumption since 1974 despite a 40 percent growth in GNP (see Figure 1). For the most part, these investments occurred in industry, transportation, commercial buildings, and residences when fuel was a very significant operating cost, and at the same time, when the payback for such an investment could be realized quickly.

In short, many actions taken were easy marks. While some of these actions were changes in patterns of energy use, such as lowering thermostats, most were investments in technology that pay off year after year requiring essentially no change in lifestyle: either retrofits, such as insulating existing homes, or new investments, such as energy efficient new construction or autos with improved mileage. Indeed, more than a decade later we are still seeing the results of such investments as they continue to accumulate.

1. A number of other assessments are relevant to other provisions in S. 324, including Starpower: The U.S. and the International Quest for Fusion Energy, U.S. Natural Gas Availability: Gas Supply Through the Year 2000, Nuclear Power in an Age of Uncertainty, Industrial Energy Use, and Acid Rain and Transported Air Pollutants: Implications for Public Policy.

Figure 1

U.S. GNP-Energy Use Ratio (Cents per Thousand Btu)



The impetus to invest in energy efficiency was aided by future expectations of higher energy costs and supply uncertainty which provided a further incentive to consumers making energy-related investments. Nonetheless, while there was usually sufficient incentive to replace capital stock with more efficient technology on a life cycle cost basis, the initial capital cost was often enough of a disincentive to defer the investment until the existing equipment had to be replaced for other reasons.

The track record of public policies designed to accelerate this shift to a more energy-efficient economy has been mixed. Still the trend toward increased energy efficiency continues, despite the current period of low and stable prices, aided by the inertia of the pattern of energy efficiency investments initiated in the 1970's. However, since the rate of penetration of energy efficiency improvements has been slow, albeit steady relative to its technical potential, that technical potential is far from being fully realized.

The technical potential of energy efficiency continues to advance as well. For example, many further improvements in residential energy efficiency are clearly possible by making effective use of advances in construction (e.g., advanced windows) house designs, and high-technology appliances (high efficiency lighting, refrigerators, chillers), and many

Energy Efficiency and New Energy Technologies: J. Gibbons

other technologies. Even with falling direct Federal support² combined with an environment of low and stable energy prices, the Department of Energy estimates that improved building shells in houses and improved appliance efficiency reduced residential energy consumption by at least 7% between 1972 and 1982. Even greater advances are possible in transportation where the energy efficiency potential of automobiles and light trucks are far from being realized. Figures 2,3, and 4 illustrate the recent historical trends in energy efficiency and technical potential for homes, appliances, and motor vehicles, respectively.

While the momentum of improving energy efficiency continues in the 1980's, albeit more slowly, the investment decision environment within which such investments are made has changed substantially from that of the 1970's. In contrast to the trends in the 1970's, the energy efficiency gains and opportunities in the 1980's, which in many cases have been just as significant as those in the 1970's, are frequently being viewed as collateral benefits of investments made primarily for other reasons, i.e., those aimed at improving competitiveness of U.S. products in world markets. Moreover, the technology for energy efficiency continues to advance, so the opportunities for improvements in energy efficiency continue to expand in virtually all sectors of the economy. However, capitalizing on these opportunities at an accelerated rate, if such a strategy is judged to be

2. The Federal role in supporting energy efficiency has changed considerably since the 1970's. Since the early 1980's, direct support fell steadily from \$1.2 billion in FY79 to \$301 million in FY88 (in constant 1982 dollars).

Figure 2

U.S. Automobile Mileage (miles per gallon)

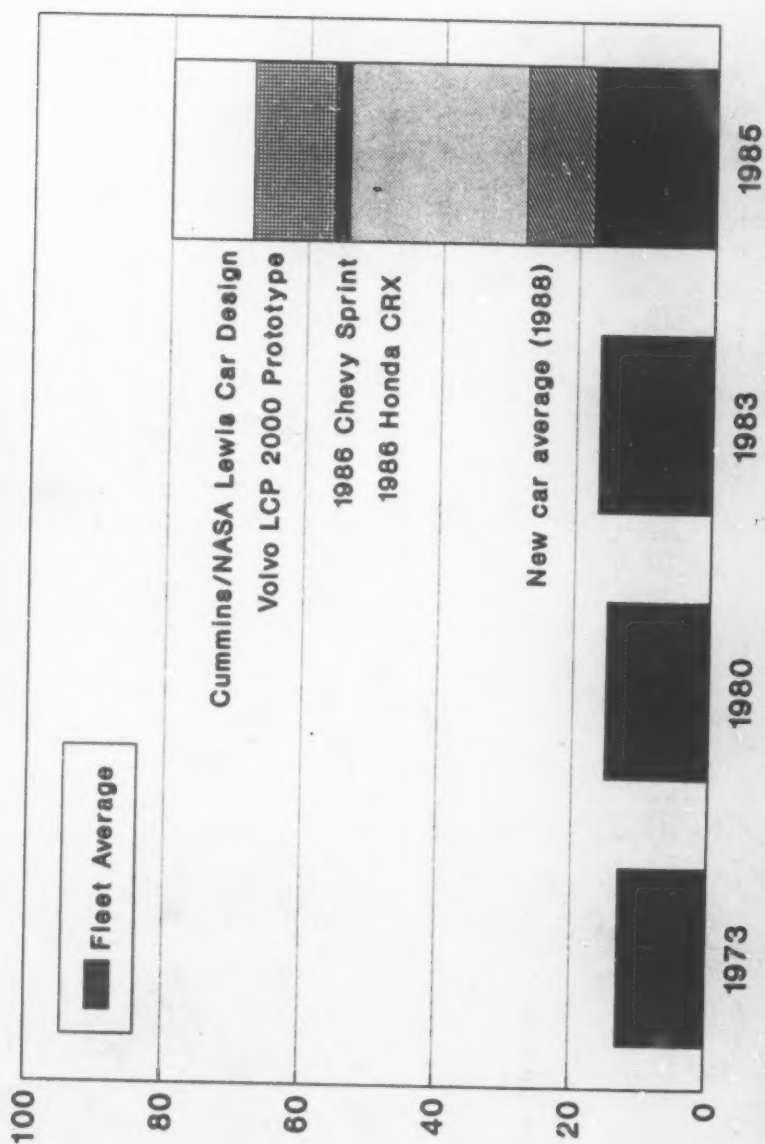


Figure 3

U.S. Residential Appliances Energy Efficiency Potential

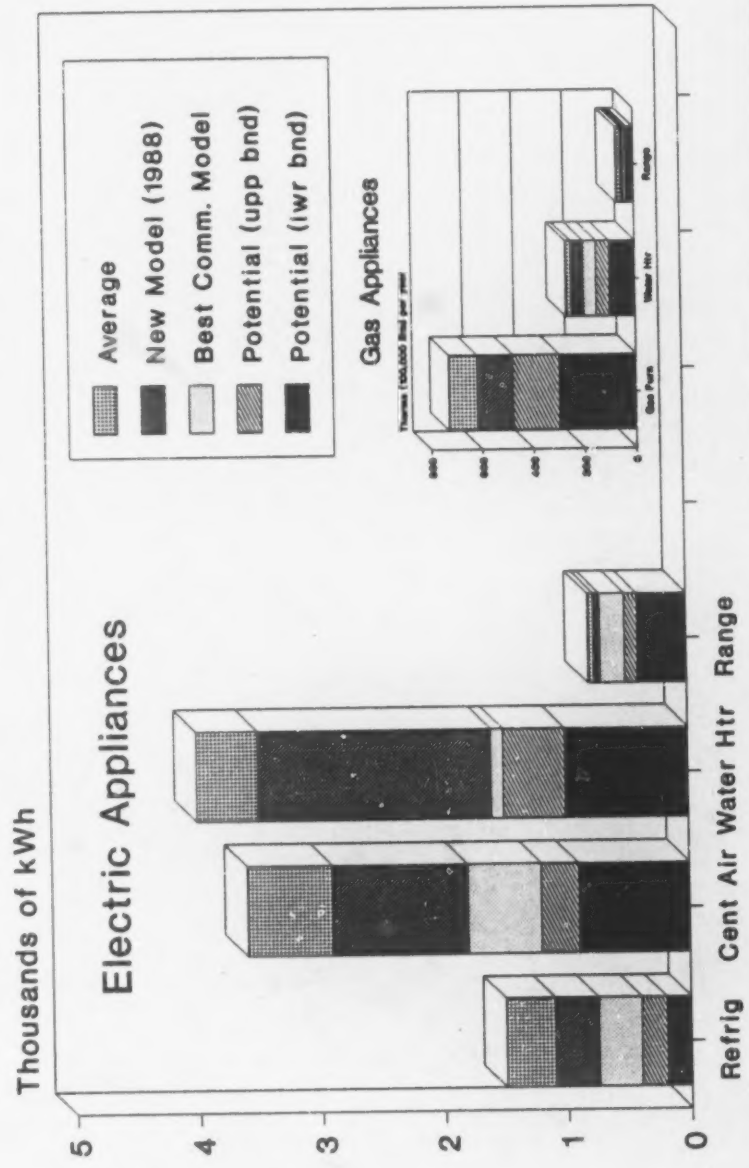
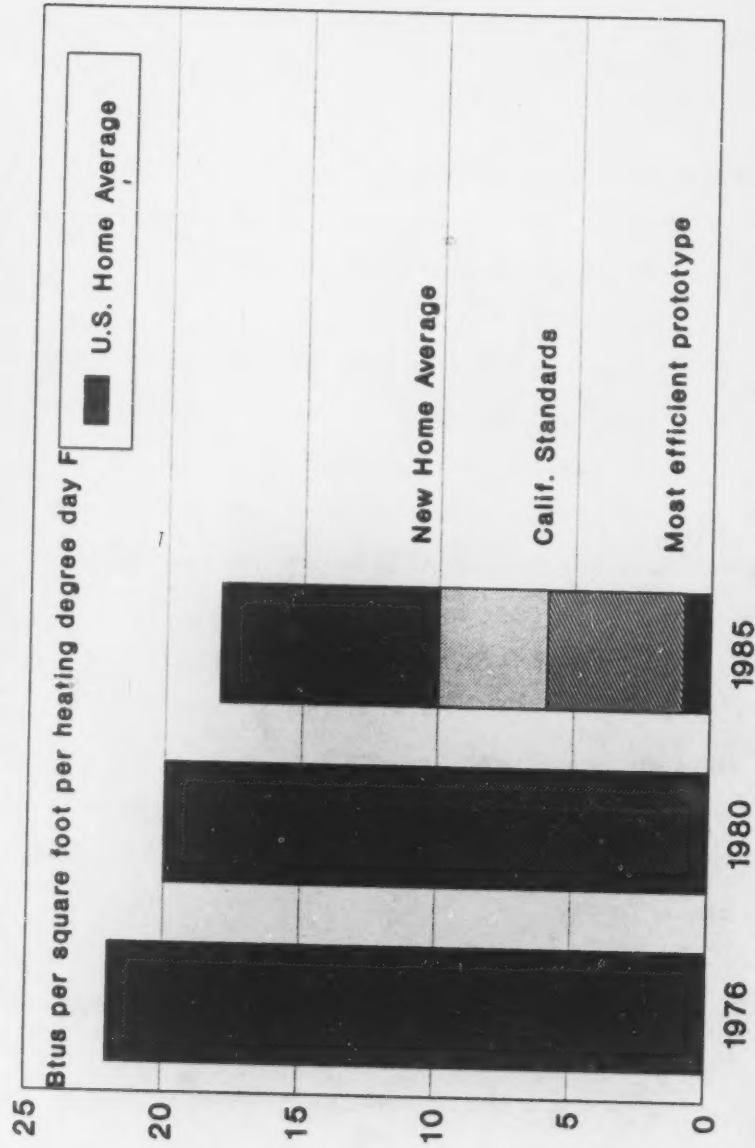


Figure 4

U.S. Residential Energy Consumption

Energy to Heat a Single Family Residence



optimal from a national perspective, will require policy intervention (e.g., research, performance standards, appliance labeling, incentives, and many of the mechanisms addressed in S. 324).

The new investment decision environment affects the relative effectiveness of policy mechanisms as well. In particular, capitalizing on energy efficiency improvements viewed as a collateral benefit of other investments provides an additional, yet somewhat different policy focus than the more traditional explicit focus on reducing import dependence, although the result is the same. That is, the policy instruments may be different. For example, low emissivity windows in new construction are much more likely to be adopted if they are easy to install in addition to having energy efficiency benefits and, hence, a research and development focus on factors such as ease of installation could be as important as energy efficiency itself in accelerating the commercial adoption of such windows.

More generally, in an environment of low and stable energy prices, the motivation to innovate comes from the pressure to be competitive and hence to turn over capital more quickly in order to maintain highly productive industry. The turnover may not be directly related to the energy efficiency improvement possible with new capital investments, but is often a natural byproduct (as are the environmental benefits of reduced CO₂ emissions). Hence, as in the windows case above, the kinds of energy efficiency improvements most likely to be adopted are those that provide

other benefits as well. For example, improved process controls in industry might be adopted primarily in order to reduce labor costs, but could have dramatic energy saving and, hence, pollution reduction benefits as well.

In sum, the policy focus for promoting energy efficiency should be two-fold: (1) to continue the long-term sustained improvements in the technical potential of energy efficiency and (2) to promote commercial adoption of the existing technical potential. And, in an environment of low and stable energy prices, the most effective near-term strategies for commercialization of energy efficiency may not be aimed at further energy efficiency improvements alone, but in addition at other factors affecting consumer decisions, such as ease of use or installation or other favorable operating characteristics.

Renewable Energy Technology

Some renewable energy technologies are already quite mature, such as hydropower, some biomass technologies, solar collectors, and passive solar design features. Others are considered to be much longer range options, or limited to very site specific applications, such as ocean thermal energy conversion, wave and tidal generators, and solar power satellites. Increased use of the mature commercial technologies is currently limited by low cost of conventional fossil fuels (example: solar heating) or availability of resources, (example: hydropower). Some renewable technologies, such as photovoltaics, geothermal and wind, have commercially available designs but these designs do not currently compete well with

traditional technologies, especially for large energy applications. Moreover, as we gain experience with some renewables, we learn more about their own adverse environmental impacts, e.g., low head hydropower's aquatic ecosystems impact and wind energy's noise impacts. Most of the commercial successes of renewables are in situations where the technologies are deployed in the most favorable resource locations such as geothermal power in The Geysers, California or wind turbines in the Altamont Pass near San Francisco. Nonetheless, many of these technologies have the potential for still further improvement in cost and performance. Finally, other renewable technologies such as solar thermal power and some advanced biomass technologies (including biomass-based synthetic liquid and gaseous fuels) have very few commercial applications, but also have great potential for improved cost and performance. Many of these possibilities are being analyzed in OTA's ongoing assessment on the future of U.S. energy supply and demand cited earlier.

The technologies in the latter two categories (those with some commercial applications and those that are "near-commercial," waiting for escalations in fossil fuel prices and continued technical development) could potentially be in a position for significant commercial application in the 1990's, but not at their current rate of technical development. For most renewables, the goal of research, development, and demonstration remains to reduce costs and increase performance so that these technologies can compete with more traditional energy sources. Performance improvements, cost reduction, and resolution of uncertainties will all

occur, but the rate at which these improvements occur will depend on sustained progress in research, development, and demonstration, and survival of an industry infrastructure.

Table 1 summarizes the current status of selected renewable technologies along with several other alternative generating technologies and the industry that supports them. Nonetheless, the last several years of low and relatively stable energy prices, coupled with declining federal and private support for research, development, and demonstration, and changes in the tax treatment of renewable energy and conservation investments, has severely diminished the sense of urgency about energy efficiency and renewable energy, and hence the rate of technical progress and near term commercial development prospects. The result has been an eroding industry infrastructure for both research and commercial development. Both the number of firms and their financial viability continues to decline. For example, in California which has traditionally been a leader in renewable resource development, in many cases only those companies holding already negotiated Standard Offer Number 4 agreements with California utilities (or the wherewithal to acquire those agreements from those who hold them) are likely to have development prospects over the next several years.

Despite all these dampening factors, technical progress still appears to be proceeding, at least for some technologies. In particular, photovoltaics continue to be sustained by interim markets of specialized

Table 1.—Cross-Technology Comparison: OTA Reference Systems

Technology characteristics	Geothermal	Wind power	Photovoltaics	Solar parabolic dish ¹	AFBC	WCC	Fuel cells	C4ES	Battery storage
General:									
Geographic location	Western U.S.	Entire U.S.	Entire U.S.	SW & SE	Entire U.S.	Entire U.S.	Entire U.S.	Entire U.S.	
Plant size ²	Small to medium	Small	Small	Small	Large	Large	Small	Medium to large	Small
Development status	Commercial	Commercial	Commercial	Demo	Commercial	Demo	Demo planned	No Demo	Plant
Lead time ³	Short to medium	Short	Medium	Medium	Long	Long	Medium	Medium to long	Medium
Start-up time ⁴	Low	Yes	Yes	Yes	Medium	Medium	High	Medium	High
Intermittent ⁵	No	Yes	Yes	Yes	No	No	No	No	No
Cost:									
Coal ⁶	Medium	Medium	High	High	Low	Low	High	Medium	Low
Coal ⁷	No	Yes	No	No	Yes	N/A	No	N/A	N/A
Problems ⁸	No	Yes	No	No	Yes	Yes	No	Medium	Low
Resource requirements and environmental impacts ⁹	Medium	Medium	High	High	Low	Low	High	Medium	Low
Primary fuel source	Geothermal	Wind	Solar	Solar	Coal	Coal	Natural gas	Base load electricity plus natural gas or oil	Base load electricity
Fuel availability	Limited	Limited	Limited	Limited	Limited	Limited	Limited	Limited	Limited
Number of units	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Size of units	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Air quality	Medium to high	Low	Low	Low	Medium	Medium	Low	Low	Low
Water quality	Medium to high	Low	Low	Low	Medium	Medium	Low	Low	Low
Water consumption ¹⁰	Low to high	Low	Low	Low	Medium	Medium	Low	Low	Low
Daily amount ¹¹	Low	Low	Low	Low	Medium	Medium	Low	Low	Low
Amount per kilowatt ¹²	High	Low	Low	Low	Medium	Medium	Low	Low	Low
Land use	Low	Low	Low	Low	Medium	Medium	Low	Low	Low
Acid rain ¹³	Low	Low	Low	Low	Medium	Medium	Low	Low	Low
Power density ¹⁴	Low	High	High	High	Medium	Medium	Low	Low	High

¹ Figures estimated based on data from the U.S. Department of Energy, Office of Technology Assessment, "Solar Energy: A Cross-Technology Comparison," OTA Reference Systems, 1980.

² Plant size is based on the number of units and the size of each unit. The size of each unit is based on the number of units and the size of each unit.

³ Lead time is the time from the start of construction to the start of operation. The lead time is based on the number of units and the size of each unit.

⁴ Start-up time is the time from the start of operation to the start of production. The start-up time is based on the number of units and the size of each unit.

⁵ Intermittent is the time from the start of production to the start of operation. The intermittent time is based on the number of units and the size of each unit.

⁶ Cost is the cost of the technology. The cost is based on the number of units and the size of each unit.

⁷ Coal is the cost of the technology. The coal cost is based on the number of units and the size of each unit.

⁸ Problems are the problems associated with the technology. The problems are based on the number of units and the size of each unit.

⁹ Resource requirements and environmental impacts are the resource requirements and environmental impacts of the technology. The resource requirements and environmental impacts are based on the number of units and the size of each unit.

¹⁰ Primary fuel source is the primary fuel source of the technology. The primary fuel source is based on the number of units and the size of each unit.

¹¹ Fuel availability is the fuel availability of the technology. The fuel availability is based on the number of units and the size of each unit.

¹² Number of units is the number of units of the technology. The number of units is based on the number of units and the size of each unit.

¹³ Size of units is the size of units of the technology. The size of units is based on the number of units and the size of each unit.

¹⁴ Air quality is the air quality of the technology. The air quality is based on the number of units and the size of each unit.

¹⁵ Water quality is the water quality of the technology. The water quality is based on the number of units and the size of each unit.

¹⁶ Water consumption is the water consumption of the technology. The water consumption is based on the number of units and the size of each unit.

¹⁷ Daily amount is the daily amount of the technology. The daily amount is based on the number of units and the size of each unit.

¹⁸ Amount per kilowatt is the amount per kilowatt of the technology. The amount per kilowatt is based on the number of units and the size of each unit.

¹⁹ Land use is the land use of the technology. The land use is based on the number of units and the size of each unit.

²⁰ Acid rain is the acid rain of the technology. The acid rain is based on the number of units and the size of each unit.

²¹ Power density is the power density of the technology. The power density is based on the number of units and the size of each unit.

²² High efficiency is the high efficiency of the technology. The high efficiency is based on the number of units and the size of each unit.

²³ Low efficiency is the low efficiency of the technology. The low efficiency is based on the number of units and the size of each unit.

²⁴ Medium efficiency is the medium efficiency of the technology. The medium efficiency is based on the number of units and the size of each unit.

²⁵ Very high efficiency is the very high efficiency of the technology. The very high efficiency is based on the number of units and the size of each unit.

²⁶ Very low efficiency is the very low efficiency of the technology. The very low efficiency is based on the number of units and the size of each unit.

²⁷ High cost is the high cost of the technology. The high cost is based on the number of units and the size of each unit.

²⁸ Low cost is the low cost of the technology. The low cost is based on the number of units and the size of each unit.

²⁹ Medium cost is the medium cost of the technology. The medium cost is based on the number of units and the size of each unit.

³⁰ Very high cost is the very high cost of the technology. The very high cost is based on the number of units and the size of each unit.

³¹ Very low cost is the very low cost of the technology. The very low cost is based on the number of units and the size of each unit.

³² High resource requirements are the high resource requirements of the technology. The high resource requirements are based on the number of units and the size of each unit.

³³ Low resource requirements are the low resource requirements of the technology. The low resource requirements are based on the number of units and the size of each unit.

³⁴ Medium resource requirements are the medium resource requirements of the technology. The medium resource requirements are based on the number of units and the size of each unit.

³⁵ Very high resource requirements are the very high resource requirements of the technology. The very high resource requirements are based on the number of units and the size of each unit.

³⁶ Very low resource requirements are the very low resource requirements of the technology. The very low resource requirements are based on the number of units and the size of each unit.

³⁷ High environmental impacts are the high environmental impacts of the technology. The high environmental impacts are based on the number of units and the size of each unit.

³⁸ Low environmental impacts are the low environmental impacts of the technology. The low environmental impacts are based on the number of units and the size of each unit.

³⁹ Medium environmental impacts are the medium environmental impacts of the technology. The medium environmental impacts are based on the number of units and the size of each unit.

⁴⁰ Very high environmental impacts are the very high environmental impacts of the technology. The very high environmental impacts are based on the number of units and the size of each unit.

⁴¹ Very low environmental impacts are the very low environmental impacts of the technology. The very low environmental impacts are based on the number of units and the size of each unit.

⁴² High primary fuel source is the high primary fuel source of the technology. The high primary fuel source is based on the number of units and the size of each unit.

⁴³ Low primary fuel source is the low primary fuel source of the technology. The low primary fuel source is based on the number of units and the size of each unit.

⁴⁴ Medium primary fuel source is the medium primary fuel source of the technology. The medium primary fuel source is based on the number of units and the size of each unit.

⁴⁵ Very high primary fuel source is the very high primary fuel source of the technology. The very high primary fuel source is based on the number of units and the size of each unit.

⁴⁶ Very low primary fuel source is the very low primary fuel source of the technology. The very low primary fuel source is based on the number of units and the size of each unit.

⁴⁷ High fuel availability is the high fuel availability of the technology. The high fuel availability is based on the number of units and the size of each unit.

⁴⁸ Low fuel availability is the low fuel availability of the technology. The low fuel availability is based on the number of units and the size of each unit.

⁴⁹ Medium fuel availability is the medium fuel availability of the technology. The medium fuel availability is based on the number of units and the size of each unit.

⁵⁰ Very high fuel availability is the very high fuel availability of the technology. The very high fuel availability is based on the number of units and the size of each unit.

⁵¹ Very low fuel availability is the very low fuel availability of the technology. The very low fuel availability is based on the number of units and the size of each unit.

⁵² High number of units is the high number of units of the technology. The high number of units is based on the number of units and the size of each unit.

⁵³ Low number of units is the low number of units of the technology. The low number of units is based on the number of units and the size of each unit.

⁵⁴ Medium number of units is the medium number of units of the technology. The medium number of units is based on the number of units and the size of each unit.

⁵⁵ Very high number of units is the very high number of units of the technology. The very high number of units is based on the number of units and the size of each unit.

⁵⁶ Very low number of units is the very low number of units of the technology. The very low number of units is based on the number of units and the size of each unit.

⁵⁷ High size of units is the high size of units of the technology. The high size of units is based on the number of units and the size of each unit.

⁵⁸ Low size of units is the low size of units of the technology. The low size of units is based on the number of units and the size of each unit.

⁵⁹ Medium size of units is the medium size of units of the technology. The medium size of units is based on the number of units and the size of each unit.

⁶⁰ Very high size of units is the very high size of units of the technology. The very high size of units is based on the number of units and the size of each unit.

⁶¹ Very low size of units is the very low size of units of the technology. The very low size of units is based on the number of units and the size of each unit.

⁶² High air quality is the high air quality of the technology. The high air quality is based on the number of units and the size of each unit.

⁶³ Low air quality is the low air quality of the technology. The low air quality is based on the number of units and the size of each unit.

⁶⁴ Medium air quality is the medium air quality of the technology. The medium air quality is based on the number of units and the size of each unit.

⁶⁵ Very high air quality is the very high air quality of the technology. The very high air quality is based on the number of units and the size of each unit.

⁶⁶ Very low air quality is the very low air quality of the technology. The very low air quality is based on the number of units and the size of each unit.

⁶⁷ High water quality is the high water quality of the technology. The high water quality is based on the number of units and the size of each unit.

⁶⁸ Low water quality is the low water quality of the technology. The low water quality is based on the number of units and the size of each unit.

⁶⁹ Medium water quality is the medium water quality of the technology. The medium water quality is based on the number of units and the size of each unit.

⁷⁰ Very high water quality is the very high water quality of the technology. The very high water quality is based on the number of units and the size of each unit.

⁷¹ Very low water quality is the very low water quality of the technology. The very low water quality is based on the number of units and the size of each unit.

⁷² High water consumption is the high water consumption of the technology. The high water consumption is based on the number of units and the size of each unit.

⁷³ Low water consumption is the low water consumption of the technology. The low water consumption is based on the number of units and the size of each unit.

⁷⁴ Medium water consumption is the medium water consumption of the technology. The medium water consumption is based on the number of units and the size of each unit.

⁷⁵ Very high water consumption is the very high water consumption of the technology. The very high water consumption is based on the number of units and the size of each unit.

⁷⁶ Very low water consumption is the very low water consumption of the technology. The very low water consumption is based on the number of units and the size of each unit.

⁷⁷ High daily amount is the high daily amount of the technology. The high daily amount is based on the number of units and the size of each unit.

⁷⁸ Low daily amount is the low daily amount of the technology. The low daily amount is based on the number of units and the size of each unit.

⁷⁹ Medium daily amount is the medium daily amount of the technology. The medium daily amount is based on the number of units and the size of each unit.

⁸⁰ Very high daily amount is the very high daily amount of the technology. The very high daily amount is based on the number of units and the size of each unit.

⁸¹ Very low daily amount is the very low daily amount of the technology. The very low daily amount is based on the number of units and the size of each unit.

remote applications and consumer electronics. Prospects for more extensive applications in remote areas appear likely as well, which provides the incentive for major industry sponsors, such as Solarex and Chronar, to stay active and to continue progress toward lower cost. Similarly, the success of small binary geothermal power units, on the heels of mature commercial development of vapor dominated resources at The Geysers, have kept some spirits alive for geothermal industry (e.g., in Hawaii). Other renewable technologies, however, have not fared as well. For example, the lack of interim or subsidized markets has brought research in solar thermal and wind energy as well as its commercial development to a virtual standstill, with only a few exceptions. The uncertainty in oil prices has exacerbated the renewable industry's problems in that no dependable price "floor" exists against which renewable technology cost and performance can be reliably compared.

The current low oil prices have also brought privately financed research, development and demonstration of biomass synthetic fuels to a virtual standstill. There has been renewed interest in several biomass technologies in the last year, however, but not so much for reasons of energy supply. Instead, urban solid waste disposal problems have prompted renewed interest in municipal solid waste power plants, although the availability of effective separation and emission control technologies is still an important concern. Similarly, local air quality concerns have provided the stimulus for renewed interest in alternative transportation fuels in some urban non-attainment areas, although the continued low cost

of conventional fuels and the likely competition from coal-based synfuels remain as serious obstacles for biomass-based alternatives. Nonetheless, automobiles and trucks now comprise 63 percent of U.S. oil consumption (and transportation accounts for 28 percent of total energy consumption), so promoting a diversity of alternative fuels for oil replacement remains very important and the consideration of CO₂ emissions may be an important factor in the selection of appropriate alternative fuels.

CURRENT RESEARCH AND DEVELOPMENT POLICY CONTEXT

The current U.S. strategy for developing both conservation and renewable technologies assumes that there is adequate time to let private development efforts fill energy supply gaps as they appear. This strategy, however, may not be sufficiently sensitive to the concerns which in the past stimulated special interest in these technologies. In particular, private industry cannot be expected to explicitly include environmental concerns or non-market considerations of foreign policy and national security prominently in corporate investment decisions. The Federal government plays the principal role in encouraging and sponsoring technology development for such reasons. Of particular concern is assuring availability of liquid fuels as substitutes for oil and improving efficiency in the use of oil, on which virtually our entire transportation system relies. Another concern is finding more environmentally acceptable ways to generate electricity. The current period of low and stable world oil prices, relative to the 1970's, has provided a window of opportunity

(but not the market "pull") for developing supply substitutes and more efficient end use technologies, to ensure commercial availability of these technologies in the 1990's.

In the early 1980's the policy tools thought most appropriate for accelerating commercial availability of alternative technologies were direct energy policy initiatives, such as technology-specific tax incentives, loan guaranty programs, etc. The most effective policy initiatives may no longer necessarily focus explicitly on energy attributes alone. Instead, as noted earlier, the consideration of other attributes (such as ease of use or installation, for example) in making investment decisions considering alternative technology and energy efficiency are now much more important. Indeed, OTA's 1983 study on industrial energy use found that direct incentives rarely affected investment decisions.

Perhaps viewing energy alternatives and improved energy efficiency as a collateral benefit to more general economic efficiency has really been the case all along and policy makers weren't sufficiently sensitive to it. Nonetheless, such a perspective ultimately affects the focus of research and development as well, since the kinds of technologies most likely to thrive in such an environment are in many cases different from those most attractive in an environment of urgency about energy. Indeed, decision makers can afford to be more discriminating and demand higher standards of new equipment, thus requiring even more emphasis on commercial demonstration of new technologies.

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The fundamental structural changes that have occurred in the U.S. economy over the last decade also have had a profound impact on the relative effectiveness of energy policy tools. For example, the technology-specific initiative of the 1970's, such as the geothermal loan guarantees or the conservation tax credits, seem strangely anachronistic when compared with more general economic incentives promoting economic competitiveness in world markets that collaterally promote energy efficiency or alternative technology.

FEDERAL ROLE IN RESEARCH, DEVELOPMENT AND DEMONSTRATION

Among the most important conditions necessary to sustain conservation and renewable energy technology development in the United States is a sustained Federal presence in research, development, and demonstration (RD&D). While many of these technologies are no longer in the basic research phase, development hurdles are still formidable and the importance of RD&D remains high. OTA's 1985 report, New Electric Power Technologies: Problems and Prospects for the 1990s, identified a number of alternative policy options aimed at accelerating the commercial availability of a range of new electric power technologies. These options apply in many respects to other new energy technologies as well since they focus on reducing cost, improving performance and resolving uncertainty in both cost and performance. A key to sustained progress in research and development is providing a stable environment for support, so that long-

term research ideas can be encouraged or at least not penalized. Recently, the desire to reduce CO₂ emissions has affected the traditional priorities for research and development among energy supply and demand technologies as well.

CO₂ Emissions Reduction Potential and R&D Priorities

There appear to be five general strategies for reducing the CO₂ emissions currently being considered by researchers:³

1. Reduce fossil fuel consumption through increases in end-use energy efficiency.
2. Replace fossil fuel combustion with alternative energy sources.
3. Shift current fossil fuel mix from high to low CO₂ emitting fuels, e.g., natural gas.
4. Reverse the current deforestation trend.
5. Dispose CO₂ in deep ocean.

3. United Nations and World Meteorological Organization, "Developing Policies for Responding to Climatic Change," WCIP-1, April, 1988.

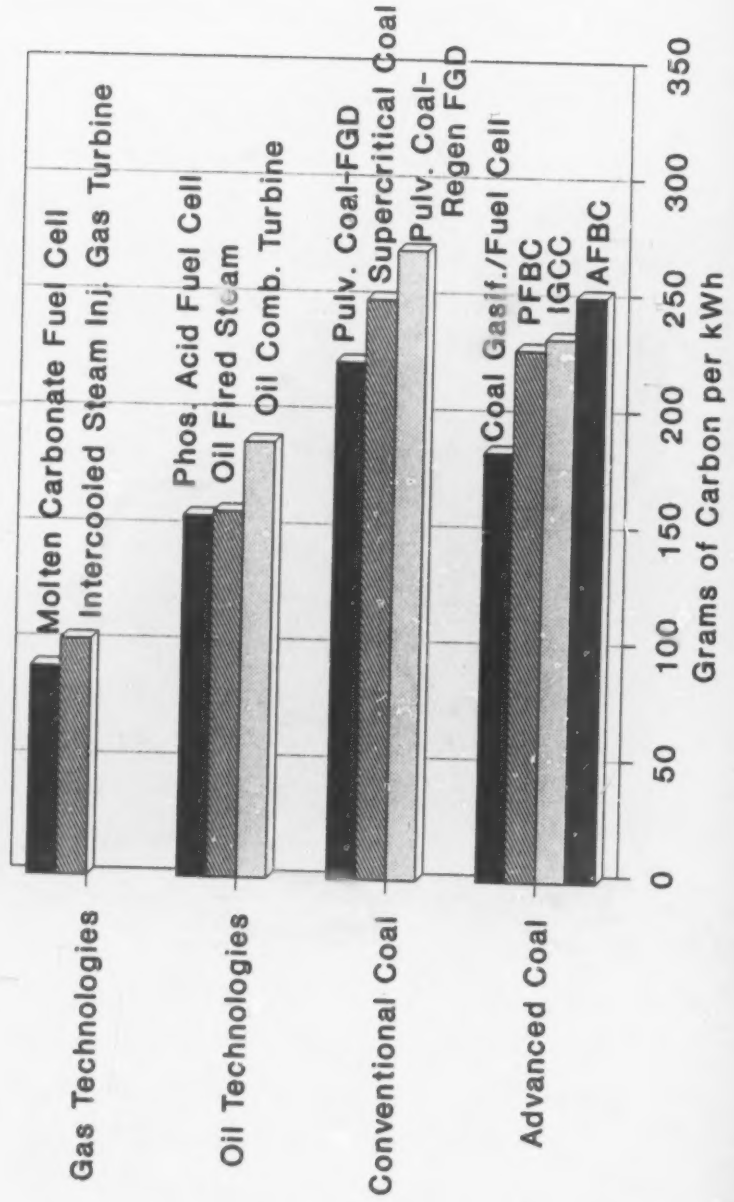
All these strategies depend, at least in part, on the availability of energy supply and end use technologies not currently in widespread use. However, the traditional priorities placed on new energy technologies are quite different from those consistent with CO₂ emission reduction. Figure 5 illustrates the emission reduction potential for a range of new electric power generating technologies. Even advanced coal technologies emit twice as much CO₂ per kWh generated as gas-fired technologies.

Demonstration

A critical milestone in commercial acceptance of these technologies is completion of a successful demonstration program. While there is considerable debate in the energy industry over what constitutes adequate demonstration, two basic categories are often distinguished. One is a proof-of-concept phase which provides the basic operational data necessary for commercial designs as well as test facilities designed to prove the viability of the technology under non-laboratory conditions and to reduce cost and performance uncertainties. The other involves multiple applications of a more or less mature technology designed to stimulate commercial adoption of the technology. Generally, activities in the first category are necessary to demonstrate commercial viability and activities in the second category are necessary to accelerate commercial development. Both are necessary for significant commercial adoption.

Figure 5

CO₂ Emissions for Alternative Electric Generating Technologies



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The length of the appropriate demonstration period will vary considerably by technology. However, the nature of the demonstration program--who is participating, who is responsible for managing it, and the applicability of the program to a wide variety of operating circumstances--is of equal importance.

Generally, OTA has found that successful demonstration programs have the following characteristics:

- o The private sector should have considerable influence in the selection of technologies for demonstration as well as principal responsibility for demonstration program design and management of the demonstration project itself.
- o Cost sharing between government and industry has generally proved successful in ensuring both careful selection of the most competitive projects and timely completion of the projects.
- o Private sector proprietary rights and ownership should be preserved, provided that such protection does not inhibit timely development of the technology.
- o Federal government commitments to a demonstration program should be stable and predictable, i.e., once made, such commitments should be

honored for a sufficient period in order to convince developers that government is a "reliable partner."

- o First-of-a-kind, full scale demonstration facilities should include support by all partners involved in the demonstration for not only plant engineering and construction but also for extended plant operations.

Smaller modular plant designs, where possible, are very attractive for demonstration projects since they normally require a smaller capital commitment than large central station designs. In addition, successful demonstration projects have included active participation from a wide range of private sector interests such as architect-engineering firms, equipment manufacturers as well as the utilities themselves when appropriate.

Project Lead Times and Directed R&D to Near Term Commercial Potential

Many of new energy technologies considered in OTA's recent assessments offer the potential of sizable deployment in electric power generation applications beyond the turn of the century. At the current rate of development, however, few of these technologies are likely to be extensively put in place in the 1990's. An increase in or a refocusing of current Federal research, development, and demonstration activities could accelerate the deployment of commercial units for many technologies. This, of course, includes attention not only to the technologies themselves, but

also to manufacturing techniques and equipment necessary to produce the technologies.

Many of the energy supply technologies OTA has considered recently are in electric power generation and use. While the technologies considered in these applications encompass a wide range of sizes, scales and levels of technological maturity, for purposes of discussing appropriate policy actions, it is convenient to divide them into several basic groups:

1. Generating and storage technologies envisioned primarily for direct electric utility applications, including Integrated Gasification Combined Cycle (IGCC), large (> 100 MW) Fluidized Bed Combustors (FBC's), large (> 100 MW) Compressed Air Energy Storage (CAES) facilities, large (> 50 MW) geothermal plants, utility-owned fuel cell power plants, and solar thermal central receivers.
2. Generating and storage technologies suitable either for utility or non-utility applications, including fuel cells and small (< 100 MW) FBC's in non-utility cogeneration applications, small (< 100 MW) CAES, wind, small (< 50 MW) geothermal plants, batteries and other solar power generating technologies such as photovoltaics and smaller-scale solar thermal.
3. Longer term technologies including fusion, hydrogen and methane production from solar energy, bioengineered organisms used in

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energy conversion, magneto hydrodynamics, ocean thermal energy conversion, and others.

4. A wide variety of demand side technologies: load management, high efficiency appliances, improved automobile fuel efficiency, lighting, industrial processes and controls, etc.

An important characteristic of the first group is the likelihood of long preconstruction and construction lead times--seven to eleven years or more in some cases. This means that there may be as little as three to seven years to develop the technology and to establish in the minds of investors that the its costs, performance and other attributes fall within acceptable ranges--if there is to be significant commercial market penetration in the 1990's. Incidentally, these concerns also apply to alternative smaller-scale nuclear technologies.

The second group of technologies are likely to have shorter lead times and are often smaller in generating capacity. For increased contribution in the 1990's, however, most of these technologies will require stepped up development to reduce cost and resolve cost and performance uncertainties that concern utility decision-makers and non-utility investors.

Near term commercial deployment isn't the objective of the third group of technologies, but the sustained and stable progress in research and

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development is essential for preserving these technologies as future options.

In many cases demand side technologies have very short lead times, particularly since many of the technologies are off-the-shelf. Many energy efficiency products, e.g., lighting, insulation, high efficiency appliances, and high mileage autos, are already commercially available.

Generally, the steps necessary to accelerate contribution to electricity supply vary according to the technology. With the first group of technologies' (again, defined above), it is necessary, first, to resolve cost and performance uncertainties within the next 5-6 years; and second, to shorten lead times of early commercial units. Uncertainties in cost and performance stem largely from the lack of sufficient commercial operating experience to satisfy non-utility investors and utility decision-makers. Utility decision-makers, in particular, in the wake of their experience with nuclear power, are now particularly wary of new technology, especially large scale technology, and they impose rigorous performance tests on technology investment alternatives. This conservatism confers added importance to advanced commercial demonstration projects.

On the other hand, no significant acceleration of existing research, development and demonstration schedules for the basic designs of the IGCC, large FBC, and utility-scale geothermal plants is likely to be required for these technologies to be ready for the 1990's. Their transition from

demonstration to early commercial units, however, will have to be accelerated if the technologies are to be used in serving demand growth in the 1990's if it occurs. Variations in basic designs or more advanced designs may, of course, require additional research and development.

Lead times being experienced by early commercial projects in the first two groups of supply technologies defined above have been longer than anticipated, partially due to the time required for regulatory review. As regulatory agencies become more familiar with the technologies, and their environmental implications become clearer, the review process should become smoother and more predictable, although this is by no means guaranteed as evidenced by the history of other generating technologies. If there is accelerated demand growth, however, it may be necessary to reduce these lead times to avoid power shortages. Action to educate regulators about each technology's impacts and benefits in the course of demonstrations might reduce the lead times of early commercial units.

For smaller scale generating technologies, where cost and performance are of particular concern, one approach to accelerating development would be to increase or concentrate Federal research and development efforts on those technologies. This could be particularly effective for photovoltaics, solar thermal parabolic dishes, and advanced small geothermal designs.

Assistance to Vendors Marketing to Foreign Countries

The new generating technologies that appear to show the most promise for substantial deployment in the 1990's are those that currently serve or have the opportunity to serve markets beyond the domestic utility grid. Such markets are especially important while demand for new electric generating capacity continues to be low and while cost and performance of these technologies are uncertain in grid-connected applications. For some of these technologies these markets are foreign. Efforts on the part of the U.S. government to assist in improving access to markets for new generating technology equipment in foreign countries could be very important to the near time viability of some of these technologies. Such efforts might include support for formation of renewable export trading companies, loan guarantees, information dissemination, and help with joint venture and licensing applications in foreign countries.

The pressures of competition from foreign vendors, many of which are heavily supported by their governments, as well as the current lack of U.S. demand for some of these new technologies in grid connected power generation applications raises the concern over the continued commitment of U.S. firms to developing these technologies. This concern is heightened by the recent changes in favorable tax treatment for renewable energy sources. For some domestic firms who are working on technologies such as wind, solar thermal electric, and photovoltaics, the survival of some domestic firms may be at stake. They may not be able to or willing to compete in world

markets over the next decade. However, they may depend upon those more limited markets until their technologies can compete in the U.S. grid-connected power generation market.

Resource Assessment Efforts for Renewable Energy

In those regions where renewable energy sources show promise for commercial application, a well defined resource is essential for assessing the economics of proposed wind, geothermal, and solar power generating projects. For example, there can be a several hundred percent difference in the calculated energy that would be generated by the same wind machines using different distributions of the same annual mean wind speed; an untested site may require up to three years of data to confirm the extent and nature of the wind resource at that site.

Reliable resource data lessens the uncertainty in energy production and hence the risk of insufficient project revenues. Some industry observers feel that, at least in the case of wind, "knowledge of the wind resource - its location and intensity - is the cornerstone to the development of wind energy." Lack of a well-defined resource base is also an important factor in geothermal development and, to a lesser extent, in solar thermal electric and photovoltaic development.

Improve Collection, Distribution, and Analysis of Information

A serious disadvantage facing all the developing technologies is the lack of adequate information on the technologies and their markets among those whose decisions are important to their commercial deployment-- investors, regulators, academicians, the general public and others.

Non-utility market information, in particular, is generally not available because these markets are not yet well developed. The lack of information increases the general level of uncertainty and risk, and favors conventional technologies and markets about which more is known.

Programs designed to deliver accurate and useful information in a timely manner to the relevant individuals and groups would be helpful in accelerating deployment of the technologies. Also, efforts to increase the capability to use the information properly could be effective. Such efforts might include the training of individuals, the development of appropriate analytical methods, and acquainting people with the technology through demonstration projects.

CONCLUSIONS

The concern about the growing evidence that greenhouse gas emissions, mostly from burning fossil fuels, are substantial contributors to the global warming provides a new incentive for efforts to reduce the Nation's

dependence on such fuels in addition to the more historic (and still valid) concerns about economic vulnerability and national security. Indeed, a combination of considerations makes it seem to be an appropriate time to redouble currently modest efforts to both mine the considerable resource of energy efficiency still possible in virtually all sectors of the economy and preserve the ability to develop renewable energy resources. This combination includes not only the increasing concern over global warming, but also the environmental impact of burning fossil fuels in the context of both the shorter term acid rain problem for coal, the level of oil imports and its role in the Nation's trade balance, the national security concern over where future world oil production is concentrated, i.e., the Middle East, and finally the need to innovate in industry to be more competitive in world markets.

Nonetheless, we still have not fully gauged the role of burning fossil fuels relative to the other sources of greenhouse gases and, hence, a consensus for action has not materialized. Moreover, the current period of low and stable world oil prices masks other senses of urgency about energy issues, especially a rapidly growing reliance on foreign oil. Hence, little is likely to happen without substantial policy intervention. As it stands now, for example, U.S. gasoline taxes and pump prices in real terms are less than they were in 1972, before the oil embargoes. The rationale for such policy intervention is not likely to come from just one of the concerns cited above alone, but rather consideration of a combination of them could collectively serve to elevate the importance of policy

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initiatives aimed at further improving U.S. energy efficiency and independence. Important among these policy initiatives is continued attention to the RD&D agenda for energy efficiency. Even a broad policy approach aimed at improving U.S. economic efficiency will require continuing technical improvements in energy efficiency as one of its components. S. 324 provides a useful framework for constructing such an agenda.

Renewable energy technologies also remain important elements of the Nation's long term energy supply strategy. Maintaining the potential for increased contribution to U.S. energy supply and even maintaining a viable industry infrastructure for these technologies will require sustained research and development support. Increased contribution of these technologies in the 1990's will require accelerated research, development, and particularly, demonstration.

* * *

Senator WIRTH. Thank you, Dr. Blair. Dr. Williams, you had a long and very impressive formal statement, which we will have included in the record. And we appreciate any summary that you think would be appropriate for the committee. Thank you very much.

STATEMENT OF DR. ROBERT H. WILLIAMS, CENTER FOR ENERGY AND ENVIRONMENTAL STUDIES, PRINCETON UNIVERSITY

Dr. WILLIAMS. Thank you, Mr. Chairman. I am pleased to have the opportunity to participate in this hearing.

I am a senior research scientist at Princeton University's Center for Energy and Environmental Studies where I head a research group on energy policy and technology assessment. And our research activities are dealing with long-term global energy strategies consistent with the solutions of other important global problems with strong links to energy, including promoting sustainable development of developing countries, minimizing the global security risks associated with over-dependence on Middle East oil, minimizing the climatic risks associated with over-dependence on fossil fuels, and minimizing the nuclear weapons proliferation risks associated with over-dependence on nuclear power.

And in this we have focused on three strategies, one is improved efficiency of energy use in both industrialized and developing countries, the use of advanced gas turbines for power generation and hydrogen produced via electrolysis with electricity generated in thin-film photovoltaic cells.

In light of the shortness of the time and the fact that many of my colleagues today will be testifying on end-use efficiency, I would like to restrict my remarks to the latter two areas of my testimony having to do with gas turbines and with hydrogen-produced using photovoltaics.

As far as gas turbines are concerned and the greenhouse warming problem is concerned, this technology has some critical importance in light of the fact, first of all, that one-third of all the U.S. CO₂ emissions come from the power sector and some of the most impressive reductions in the power sector over the course of the next couple of decades can come by bringing about a shift from the way we generate power at present with thermal power plants based on steam turbines to the use of gas turbines.

Secondly, the gas turbines technology will involve very significant opportunities for cost reduction, both operating costs through improved efficiency and also very significant capital cost reduction compared to conventional steam plants.

And finally, there are very significant opportunities for reducing environmental insults. If you operate state-of-the-art gas turbines on natural gas, you can reduce CO₂ emissions relative to existing coal steam plants by about 60 percent. If you operate technologies based on gas derived from coal that could be commercialized within a decade, you can reduce CO₂ emissions per kilowatt hour compared to conventional coal steam plants by about 20 percent. If you use biomass gasified in these gas turbines and you grow the biomass on a renewable basis, you can reduce the emissions to essentially zero as a replacement of fossil fuels.

In looking at gas turbines, it is useful to distinguish between two types of gas turbines. One are heavy-duty industrial gas turbines that are specifically designed for stationary power applications and, second, aeroderivative gas turbines that are derived from jet engines. In most of our energy applications to date, the gas turbines that have been used are the heavy-duty industrial gas turbines.

While both kinds of turbines are going to have very important uses in our energy applications both for central station power generation and for cogeneration, I think much greater emphasis should be given in the future to aeroderivatives, and there are several reasons for this.

One is that there are very significant improvements being made in jet engine technology, improvements that can be brought to bear in stationary power applications much more quickly and at much lower cost by emphasis on aeroderivatives. The main reason for this has to do with the fact that the Department of Defense spends about a half a billion dollars per year on jet engines for military aircraft applications in this country. And we now lead the world in aircraft engine technology by a very wide margin. For example, U.S. manufacturers account for about 90 percent of the total market in the world of jet engines used in commercial aircraft. We have not yet very significantly exploited this competitive advantage in the stationary power applications.

I was pleased to see in S. 324 that one particular aircraft derivative gas turbine was highlighted for emphasis, and that was the inter-cool steam-injected gas turbine for natural gas firing. I think this is important, but this is just beginning of a continuing stream of innovations that could occur in this area if we put some effort into R&D and, in particular, some commercial demonstrations.

But I would like to turn from natural gas, which was I think adequately highlighted in bill, to tell you a little bit about a class of gas turbines that requires considerable emphasis, and it is all but neglected at the present time, and this is gas turbines that are based on the use of biomass.

And one of the reasons for emphasizing biomass is that progress can be made very quickly in this area because of the hundreds of millions of dollars of R&D that have already been spent on trying to marry coal to gas turbines through coal gasification via the clean coal technology program and also private sector R&D efforts in this area. The same technology can be applied to biomass very quickly and, in fact, it can be brought to commercialization much more quickly than the corresponding coal technologies largely because of the fact that the biomass contains no sulfur and it is the cost-effective removal of sulfur that is the major impediment to the rapid commercialization of the advanced coal gasification gas turbine technology.

A second reason for emphasizing the aeroderivative turbines in thinking about biomass is that if you are going to do this efficiently, you absolutely have to have the aeroderivative turbine. And the reason for this is that biomass-based electric power generation has to be conducted on scales that are much smaller than the scales that are characteristic of central station power generation based on fossil fuels. So, a 50 megawatt power plant is going to be a large power plant based on the use of biomass. A 100 megawatt power

plant is going to be sort of the upper bound. In order to bring about very favorable economics with gas turbine-based power generation at that small scale, you have to go to the aeroderivatives. The aeroderivatives, because they are based on aircraft engines, bring high performance and low unit capital cost into that size range.

Another reason for emphasizing biomass has to do with the fact that biomass modernization as an energy source is going to be one of the most effective ways of promoting development in developing countries, especially rural development, bringing cost-effective energy supplies into rural areas in developing countries. In looking over the course of the next couple of decades, the most effective way of doing this is to use advanced technology for power generation, because we cannot do other things such as making liquids from biomass, until the oil price at least doubles from where it is at the present time. We can bring power generation technology to market within the course of the next four or five years, and it would be instantly competitive with the conventional alternatives.

And then finally, another reason for emphasizing biomass is, of course, the benefit with regard to the greenhouse problem. And here there are actually three ways in which the biomass-based strategies can be effective. One is the obvious one, and that is that there is no net CO₂ emissions if the biomass is grown on a renewable basis.

But there are a couple of other ways that it helps as well, and one of which is that if you are to use, as biomass, trees that are grown on long rotation plantations, you can sequester a significant amount of biomass in the steady state inventory of those plantations.

And finally, there are significant opportunities for providing a very powerful incentive for reforestation by doing this. And the reason for that is very simple. If you build a power plant or any capital-intensive energy conversion facility based on biomass, that is a very large fixed investment that has to last 20 or 30 years in order to give the investors a return on their investment. And biomass has a very low energy density and it is very costly to transport the biomass long distances. And so, the producers are going to have a very powerful incentive for producing biomass on a renewable basis and locally.

One of the major things that needs to be done in this area is to conduct commercial demonstrations of this technology. But, as I say, this can be accomplished much more quickly than what can be accomplished in the area of the coal-based technology.

Senator McCONNELL. Dr. Williams, can I interrupt just one second?

Mr. Chairman, I have a number of questions I would like to submit to the witnesses to be answered for the record, if you don't mind. And I must go on.

Senator WIRTH. Absolutely. Did you have any kind of an opening statement, Senator McConnell, that you wanted to make for the purpose of the hearing?

Senator McCONNELL. No. The questions are the main thing.

Senator WIRTH. Fine. Thank you very much for joining us.

Dr. Williams?

Dr. WILLIAMS. The second technology that I wanted to focus on is the use of thin-film photovoltaic cells for producing hydrogen as an alternative to synthetic fossil fuels in the time frame near the turn of the century.

This is quite an interesting possibility at the present time that was thought to be economically uninteresting as little as a decade ago largely because of the prospects for making hydrogen this way were thought to be always too costly. But there have been some very significant gains made in both the cost and performance of solar cells based on thin films. And if you look at what the industry is projecting for the costs and performance of thin-film photovoltaic technology, especially photovoltaic technology based on amorphous silicon in the time frame near the turn of the century, then it looks as though the prospects would be quite favorable for being competitive with alternative fossil fuels and also competitive with alternative means of making hydrogen from other sources such as nuclear, wind or hydroelectric sources in that time frame.

There has been considerable emphasis given in S. 324 to hydrogen I notice, but we would suggest that the priorities that are assessed there ought to be reconsidered. In S. 324, considerable emphasis is given to hydrogen-based commercial aircraft. In our opinion that is a very interesting long-term possibility, but we think that the most significant near-term markets—by near-term I mean near the turn of the century—will not be in air transportation, but will instead be in urban transportation. And in particular, it looks like the automobile and bus and truck transport will be quite interesting applications in this time frame, and that they ought to be given particular emphasis.

And one of the important aspects of the photovoltaic hydrogen technology is that it can be introduced on relatively modest scales. There are no significant scale economies associated with photovoltaic hydrogen technology beyond a couple of tens of megawatts. And therefore, the ante for getting into the game involves investments on the order of tens of millions of dollars and not billions of dollars.

And, in fact, you don't have to wait until the turn of the century in order to get started because one interesting strategy for working on this over the next decade or so is to use off-peak power from conventional power plants to produce hydrogen and to use this hydrogen in fleet vehicles in urban centers for which there are very serious air pollution problems such as in the southwest United States. We have done in our work in this area a very detailed scenario for Phoenix, for example, showing how a combination of hydrogen vehicles and improved air pollution standards, emission standards, for automobiles would significantly be able to cope with the air pollution in a much more effective way than alternative synthetic fuel strategies.

There are some significant things that can be done in the way of public policy in this area, the most important of which I think is, of course, we can improve the competitive environment considerably for alternatives like this if we impose, for example, a carbon tax or alternative measures for restricting fossil fuels, likewise an oil tax or an oil tariff would be effective.

It turns out that energy efficiency measures are going to be extremely important in bridging a transition to a hydrogen economy, and there are two reasons for that. One is that in many areas you will find that the economics of hydrogen look much better if emphasis is given to energy efficiency. Second, in areas like transportation, especially in the case of the automobile, high fuel economy cars are essential in order to have wide penetration of hydrogen vehicles. And the reason for that has to do with the low energy density of hydrogen, and in order to get long range, you have to have high fuel economy. So, emphasis on fuel economy is absolutely essential in order to bring about a satisfactory transition to hydrogen.

I mentioned several other policy strategies in my statement, but I will leave those for the record.

[The prepared statement of Dr. Williams follows:]

INVITED TESTIMONY

by

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before the

Committee on Energy and Natural Resources

of the

U.S. Senate

March 14, 1989

Mr. Chairman, I am pleased to have the opportunity to share with this committee some ideas as to the potential for energy-efficient and renewable energy technologies.

I am a senior research scientist at Princeton University's Center for Energy and Environmental Studies, where I head a research group on energy policy and technology assessment. Our research activities are oriented toward identifying and articulating long-term global energy strategies that are consistent with the solutions of other important global problems with strong links to energy, including the challenges of:

- o promoting the sustainable development of developing countries in the face of increasingly costly energy supplies;
- o minimizing the global security risks of overdependence on Middle East oil;
- o minimizing the global climatic risks of overdependence on fossil fuels;
- o minimizing the nuclear weapons proliferation risks of overdependence on nuclear power.

Our research has focussed on three energy strategies that are consistent with these global goals:

- o improved efficiency of energy use, in developing and industrialized countries alike;
- o advanced gas turbines for power generation;
- o hydrogen produced via electrolysis with electricity generated in thin-film photovoltaic cells.

In my testimony I will discuss the prospects for progress in each of these areas.

MORE EFFICIENT USE OF ENERGY

Until recently the US was making remarkable progress in decoupling energy and economic growth. Between 1973 and 1986 the amount of energy required to produce a dollar of GNP declined at an average rate of 2.4% per year. In the more recent period, 1979-1986, the energy intensity of the economy declined at a more rapid 3.1% per year. While the decline in energy intensity has subsequently halted, the more recent cessation of progress can be attributed to current low world oil prices and virtual neglect of energy efficiency in public policy in the 1980s.

But the US can return to the track of steadily improving efficiency, as the opportunities are far from exhausted with available and near commercial technologies, and there would be many more possibilities with new technologies through continued research and development on energy end-use efficiency. Moreover, many of these new more energy-efficient technologies offer multiple, additional benefits. Two examples:

- o With commercially available superinsulated houses constructed with factory-assembled panels mounted at the construction sites on post-and-beam frames (Figure 1), space heating needs could be met with just 1/10 the fuel required for average existing houses (Table 1). In these houses uniform temperatures could be maintained throughout with the use of a couple of small space heaters--a much more costly central furnace plus ductwork system would not be needed. The savings on the heating system would partially offset the extra cost for insulation. The fuel savings would easily pay for the net extra first cost.
- o Volvo has developed a 69 mpg lightweight (1560 lb) multi-fuel capable, 2-4 passenger prototype car (LCP 2000) that has good acceleration (0 to 60 mph in 11 seconds, compared to 0 to 17 seconds for the automatic Chevrolet Cavalier) and is crashworthy (it can withstand 35-mph front and side impacts and 30 mph rear impacts--meeting stricter standards than do cars currently sold in the US). In 1985 Toyota introduced the AXV, a 98 mpg prototype (Figure 2); though less fully developed than the Volvo LCP 2000, this prototype nevertheless shows that cars with very high levels of fuel economy could be brought to market if there were demand for them. Moreover, according to Ford analysts, American manufacturers too should be able to build such cars a decade from now (*).

What is the aggregate potential for the more efficient use of energy? This question was addressed in the global context in *ENERGY FOR A SUSTAINABLE WORLD* (Wiley-Eastern, Delhi, 1988), and a summary report of the same title (World Resources Institute, 1987), the major publications of the End-Use Oriented Global Energy Project, of which I was a coorganizer, with Jose Goldemberg, Brazil (**), Thomas Johansson, Sweden (***), and Amulya Reddy, India (****).

* The following is from Emmett J. Horton (director, technical staffs, Ford Motor Company) and W. Dale Compton (vice president, research, Ford Motor Company), "Technology Trends in Automobiles," *Science*, 10 August 1984:

"So what might an 'average' vehicle of the late 1990's be like? It could be a four- to five-passenger vehicle in the 2000-pound inertial weight class with an aerodynamic drag coefficient of 0.20 or less...Electronics would control a turbocharged, ceramic, adiabatic diesel engine and continuously variable transmission to provide a smooth, effortless performance and fuel economy in excess of 100 miles per gallon on the highway."

** Rector, Univ. of Sao Paulo. Between 1983 and 1985 Goldemberg was President of the electric and gas utilities of Sao Paulo State [Companhia Energetica de Sao Paulo (CESP), Companhia Paulista de Forca e Luz (CPFL), Electricidade de Sao Paulo (ELETROPAULO), and Companhia de Gas de Sao Paulo (COMGAS)].

*** Professor of Energy Systems Analysis, University of Lund, and a Director of Vattenfall, the Swedish State Power Board.

**** Professor, Department of Inorganic and Physical Chemistry, and Chairman, Department of Management Studies, Indian Institute of Science at Bangalore.

Our principal findings were that it would be both technically and economically feasible to meet economic goals in both industrialized and developing countries to the year 2020, with about the same level of global energy use as at present. With this reduced level of global energy demand, it would be possible to greatly mitigate the serious problems associated with overdependence on oil, fossil fuels generally, and nuclear power. And this end use-oriented energy strategy would make it much easier for developing countries to meet development goals in this period.

In its report the Brundtland Commission on Environment and Development (*) criticized conventional global energy projections and adopted our perspective:

"...A near doubling of global energy consumption will be difficult without encountering severe economic, social, and environmental constraints.

This raises the desirability of a lower energy future where gross domestic product (GDP) growth is not constrained but where investment effort is switched away from building more primary supply sources and put into the development and supply of highly efficient fuel-saving end-use equipment. In this way, the energy services needed by society could be supplied at much reduced levels of primary energy production. Case B in Box 7-2 [referring to the Goldemberg, Johansson, Reddy, Williams global energy scenario] allows for a 50 percent fall in per capita primary energy consumption in industrialized countries and a 30 percent increase in developing countries...But this path would require high structural changes to allow market penetration of efficient technologies, and it seems unlikely to be fully realizable by most governments during the next 40 years.

The crucial point about these lower, energy-efficient futures is not whether they are perfectly realizable in their proposed time frames. Fundamental political and institutional shifts are required to restructure investment potential in order to move along these lower, more energy-efficient paths.

The Commission believes that there is no other realistic option open to the world for the 21st century..."

-pp. 173-174 in Our Common Future.

For the US our scenario implies that if GNP were to grow at an average rate of 2.5% per year, the energy intensity of the US economy would have to decline at an average rate of 3.3% per year, 1980-2020, slightly faster than the trend in the period 1979-1986. This would probably not be achievable

* The World Commission on Environment and Development, formed in December 1983 in response to a UN General Assembly request to formulate long-term environmental strategies, proposed policies for achieving sustainable development by the year 2000 and beyond. The Commission was chaired by Norway Prime Minister Gro Harlem Brundtland. The Commission's findings were published as World Commission on Environment and Development, Our Common Future, Oxford University Press, Oxford, 1987.

without new public policy initiatives relating to energy efficiency--including an oil tax (or tariff), a carbon tax (or the issuance of marketable carbon emissions permits), tough new measures to promote automotive fuel economy improvement, expanded utility conservation programs, increased support for R&D on energy end-use efficiency, and perhaps some novel generic strategies for promoting the marketing of energy efficiency.

The importance of identifying and trying out new generic strategies for promoting improvements in energy efficiency cannot be emphasized enough. Marketing energy efficiency is inherently more difficult than marketing electricity or other energy carriers. The use of energy throughout the economy is determined by a complex set of factors--including user preferences, incomes, and the resourcefulness and technical know-how of those who produce and sell energy-using technologies. Moreover, the technological options for providing particular energy services are varied, and they change as new technologies are developed. In short the patterns of energy use depend on decisions by large numbers of consumers, each of whom is continually confronted with having to make many scores of decisions relating to energy-using activities. This situation is far more complex than that for the production of energy, which generally involves only a few different energy forms and a relatively small number of producers.

Such complexities relating to energy services suggest the importance of generic energy-saving policies that cover a wide range of end-uses. To date the only generic policies available to promote the more efficient use of energy have involved more rational energy pricing policies. New oil or carbon taxes will also be important generic approaches to the promotion of improved end-use efficiency. But pricing strategies by themselves will not be able to cope with one of the fundamental constraints inhibiting the more efficient use of energy--the consumer reluctance to spend more up front on energy equipment purchases, even though increased first costs would be more than compensated for by subsequent reduced expenditures on energy.

Some promising new ideas have been introduced lately for overcoming this problem by nurturing the development of the embryonic energy services industry, that may one day market energy services as effectively as energy supply companies market energy carriers. One particularly intriguing idea advanced by Cicchetti and Hogan [1] would involve utilities (a) holding auctions to buy "saved energy" from energy service companies that make energy-saving investments for utility customers and (b) selling the services generated from this saved energy to the beneficiaries of the energy efficiency investments involved, in equitable ways that promote overall economic efficiency. Another attractive idea proposed by Cicchetti and Curkendall [2] would be similar but would have the utility playing the role of energy service company as well. While these proposals have practical problems associated with the satisfactory determination of the amount of energy actually saved, the proposals are so attractive on theoretical grounds that they warrant intensive experimental investigation on a priority basis, with emphasis given to the "scorekeeping" issues involved [3]. The combination of the Cicchetti/Hogan proposal and the Cicchetti/Curkendall proposal (to cover important end-use activities that non-utility energy service companies will not bid on) may well prove to be as powerful a generic strategy for promoting improved end-use efficiency as the

PURPA legislation has proven to be for promoting cogeneration.

GAS TURBINES FOR POWER GENERATION

On the supply side, there are significant opportunities for making more efficient use of energy by using advanced gas turbines for power generation as an alternative to the more familiar steam turbine, which has dominated thermal-electric power generation since the turn of the century. While there have been no improvements in the efficiency of steam turbine power generating technology since the late 1950s, there have been continual advances in gas turbine performance as a spin-off of improvements in jet engine technology. As a result of advances in turbine blade materials and turbine blade cooling technology there has been a 20 °C average annual increase in the state-of-the-art turbine inlet temperature for jet engines since the end of World War II, a trend that is expected to continue (Figure 3). This improvement is largely a result of Defense Department support for R&D on jet engines for military aircraft applications--which has averaged some \$0.5 billion dollars per year over the last decade.

These advances in jet engine technology can be transferred to gas turbines used in stationary power applications two ways. Appropriate jet engines can be modified for stationary power applications as "aeroderivative" gas turbines, or the advances in aircraft engine technology can be introduced in new heavy-duty industrial turbines that are specifically designed for stationary power applications. To date, most of this technology transfer has taken place via the latter route. However, there are good reasons for giving more emphasis to the aeroderivative turbine route.

First, while it was long believed that the high performance needed for gas turbines to be able to compete with conventional steam turbines in stationary power applications could be achieved only with the heavy-duty industrial turbines that are used in gas turbine/steam turbine combined cycles (Figure 4) [for which aeroderivative turbines are poorly suited (*)], the concept of massive steam-injection for power and efficiency augmentation, introduced

* An important distinguishing difference between modern aeroderivative and heavy-duty industrial gas turbines is that the combustors of the former operate at much higher pressures (25 atmospheres or more, compared to 12-16 atmospheres for heavy-duty industrial turbines). High pressures are needed to optimize the performance of jet engines at today's high turbine inlet temperatures. Heavy duty industrial turbines tend to be designed instead for optimal performance in the combined cycle mode. For a given turbine inlet temperature the turbine exhaust of heavy duty industrial turbines tends to be hotter and capable of producing more steam than is possible with aeroderivatives. The relatively low turbine exhaust temperatures of the aeroderivatives makes them relatively poor candidates for combined cycle configurations.

commercially for cogeneration applications in the early 1980s (*), makes it possible to achieve comparable or better performance with aeroderivatives.

Second, tightening NO_x emissions standards, which can be expected with growing concerns about urban ozone pollution, tropospheric ozone (a greenhouse gas), and acid rain, give a significant advantage to steam-injected gas turbines, for which a high level of NO_x control is automatic (because the steam injected at the fuel nozzle reduces the flame temperature), compared to the combined cycles, for which high levels of NO_x control are possible only with capital cost and efficiency penalties [4].^x

Third, as it is very costly and time-consuming to develop a new gas turbine, the transfer of aircraft engine advances to stationary gas turbine applications is accomplished far more quickly and at far less cost by using aeroderivative turbines than by designing these advances into new heavy-duty industrial turbines.

Fourth, while US industry faces tough competition in global combined cycle markets, the US has a commanding lead in aeroderivative turbine technology, as a consequence of the high level of military R&D support for jet engines (**)--an

* Like a simple cycle gas turbine used for cogeneration (Figure 5) the steam-injected gas turbine (STIG) involves the production of steam from the gas turbine exhaust heat using a heat recovery steam generator (HRSG). In simple cycle systems all this steam is used for process applications. But in the case of the STIG unit (Figure 6) steam not needed for process is injected back into the gas turbine combustor (and at further points along the flow path), where it is heated up to the turbine inlet temperature, and then passed through the turbine. With massive steam injection the gas turbine produces more power at higher electrical efficiency. STIG technology makes it possible (if the extra electricity produced when the steam load declines can be utilized) to overcome the problem of poor part-load performance that has limited the use of simple cycle gas turbines to cogeneration applications characterized by constant steam loads. PURPA in effect made the birth of STIG possible by providing a utility market for the electricity produced in excess of onsite needs.

At present there are 31 STIG units in the U.S. operating, under construction, or on order, that can burn high quality gaseous and liquid fuels. The largest STIG unit commercially available is based on the GE LM5000 aeroderivative gas turbine (derived from the jet engine used in the Boeing 747, the DC 10 Series 30, and the Airbus 300). In the simple cycle mode this turbine produces 33 MW at an efficiency of 33% (higher heating value basis) when operated on natural gas fuel. With full steam injection this engine produces 51 MW at 40% efficiency; the installed cost of this STIG unit is about \$30 million (\$600 per kW).

** So far, the major civilian spinoffs of military R&D support for jet engines have been in the commercial jet engine market, which is dominated by US producers. In 1987 GE and Pratt and Whitney accounted for 63% and 27% of the world market, respectively, compared to 10% for Rolls-Royce. See Frederick Ungeheuer, "They Make Good Things for Flying," Time, May 2, 1988 (attached as Appendix A).

advantage that has been little exploited to date.

Natural Gas Firing

At present there are no aeroderivative turbines commercially available that could compete in central station power applications with the best combined cycles on the market, which offer an efficiency of 45% on natural gas at an installed cost of about \$500 per kW at an installed capacity of about 400 MW. However, an intercooled version of a steam-injected gas turbine (ISTIG) would be able to compete. One based on a more modern version of the jet engine used in the GE LM5000 would have an efficiency of 47% at an installed cost of \$400 per kW in a plant with a capacity of only 114 MW. This could be brought to market at a cost (to design, develop, and test the first such unit) of some \$100 to \$150 million, including the capital cost of the first unit (\$46 million) [5]. And other engines offering even higher performance could soon follow [6].

RD&D in this area is likely to be characterized by very high benefit/cost ratios, for various reasons. First, much can be accomplished in modifying aircraft engines for stationary power applications by making relatively low-cost modifications of aircraft engines. Much of what needs to be done involves making relatively "low technology" cycle modifications of "high technology" jet engines that have already been developed--modifications that were not carried out in jet engine development efforts because they involve the use of steam and bulky heat exchangers that are not relevant for aircraft applications.

The cost of an ISTIG demonstration can be justified in terms of the benefits to be derived in just one important initial US market: as a replacement for existing gas-fired steam-electric power plants. It would be worthwhile to shift existing natural gas-fired steam-electric power plants to natural gas-fired ISTIG units, if the fuel savings were greater than the extra capital charges. The US DOE projects that by the year 2000 gas-fired steam-electric plants with an average efficiency of 31.8% will be producing 260 TWh in plants operating with an average capacity factor of 42% [7]. At this capacity factor it would be worthwhile to shift to ISTIG units as long as the gas price is in excess of \$3.2/GJ (Table 2). Moreover, the fuel savings would exceed the capital charges in the very first year if the gas price were greater than \$4.1/GJ (Table 2). Even though utility gas prices are low at present (averaging \$2.1/GJ in 1987), it would be economical to switch to ISTIG in most areas before the turn of the century, at which time the DOE projects that the utility gas price will average \$4.3/GJ [7]. The gas saved by making this shift would be 0.95 EJ--equivalent to 430,000 barrels of oil per day (*).

Technologies like ISTIG will also be important in global markets in the coming decades: in part because with its low carbon dioxide emissions rate

* Almost as much savings (390,000 barrels per day of oil equivalent) would result from installing 45% efficient combined cycles that are already commercially available. But at a gas price of \$4.3/GJ, the extra savings associated with the more efficient ISTIG unit would be some \$380 million per year. Thus the simple payback time for the ISTIG development cost (exclusive of the cost of the first unit) would be only 2-3 months.

(only 0.4 times as much carbon dioxide is emitted per kWh than with a conventional coal steam-electric plant) it represents a good interim technology for helping cope with the greenhouse problem; in part because its low capital unit cost makes it especially attractive for developing countries, in light of the unaffordability of capital investments for electricity based on conventional sources (Table 3); and in part because natural gas is going to be an important fuel during the transition to the post-fossil fuel era. While there is about as much natural gas left in the world as oil, gas is used at just half the rate oil is used (Table 4). A global strategy that would give more emphasis to gas and less to oil in the decades immediately ahead would help promote global security.

While the abundance of natural gas in developing countries (Table 4) suggests that natural gas could play a major role in the energy economies of many of these countries, the use of natural gas is presently inhibited by the lack of gas transmission and distribution infrastructure, which is costly to develop. This problem could often be overcome if power generation were emphasized as an initial market. Some of the large revenues generated in power sales could be used to pay for the construction of the gas delivery system, thereby helping to make gas available to other users at reasonable cost.

The scale characteristics of aeroderivative turbines are also well suited to developing countries. In most developing countries, the total utility grid capacity is too small to be well matched to much larger hydroelectric or steam-electric power plants. Adding new capacity in small increments with these gas turbines makes it possible to avoid the alternating periods of power glut and power shortage associated with utility planning based on large plants and can lead to improved system reliability.

The compact, modular nature of aeroderivative turbines makes it possible to replace failed parts and even whole engines quickly with replacements flown or trucked in from centralized maintenance facilities. This feature of the aeroderivatives is especially attractive for many developing countries, where sophisticated maintenance capability is typically unavailable at power generating sites. The required maintenance network is already in place in most developing countries that have their own commercial airlines; their planes are typically maintained through centralized lease-pool arrangements.

All such considerations suggest that there could be strong global markets for advanced aeroderivative turbine technologies fired with natural gas in the coming decades.

Coal-Gas Firing

The uncertainty about the long-term availability of natural gas at affordable prices is a major obstacle to a broad shift by utilities to advanced gas turbines, despite the continuing advances that are being made in gas turbine technology. But major progress has been made in marrying the gas turbine to coal through coal gasification. The Cool Water Project, involving

the construction and operation of a 94 MW combined cycle power plant coupled to a Texaco coal gasifier, at Cool Water, California, operated by the Southern California Edison Company as part of a joint industrial effort involving the Electric Power Research Institute (EPRI), the Bechtel Corporation, the General Electric Company, Texaco, and a Japanese consortium under the rubric the Japan Cool Water Program, has demonstrated that it is technically feasible to operate a gas turbine on gasified coal with very low pollutant emissions.

A commercial-scale (600 MW) plant using a Texaco gasifier and the best available combined cycle would be cleaner than and roughly competitive with a conventional coal-fired steam-electric power plant equipped with flue gas desulfurization [6]. Thus, in principle, utilities could shift combined cycles started up with natural gas to coal-firing with this technology if natural gas prices should get too high. However, it will be hard to persuade many utilities to take a chance on a new technology that offers no economic benefits. Accordingly, most utility planners willing to emphasize gas turbines in their capacity expansion plans are those who think that over the expected lives of these plants the chances of having to shift to gas derived from coal are remote.

This situation would be different if the coal-gas backstop technology offered significant economic advantages over conventional coal-fired steam plants. A 1986 analysis for the U.S. Department of Energy by the General Electric Corporate R&D Center offers one approach to addressing this challenge [8]. This study, which considered several gasifiers and gas turbine technologies, identified three strategies as the most promising for reducing capital costs and improving the coal-to-electricity conversion efficiency, thereby reducing overall costs: (a) replacing the oxygen-blown Texaco gasifier with an air-blown Lurgi fixed-bed gasifier, thus eliminating the need for the costly and scale-sensitive oxygen plant; (b) employing hot-gas desulfurization instead of a scrubber (cold-gas cleanup) for sulfur removal, thus improving efficiency; (c) using an ISTIG instead of a combined cycle, further improving efficiency and eliminating the scale-sensitive steam-turbine bottoming cycle for the combined cycle. With these strategies, the GE study estimated that the installed capital cost of the resulting coal-integrated gasifier/intercooled steam-injected gas turbine (CIG/ISTIG) would be about \$990 per kW (Table 5) in a 110 MW unit with an overall coal-to-busbar efficiency of 42.1% (compared to \$1500 per kW @ 37.9% efficiency for a 600 MW combined cycle plant equipped with a Texaco gasifier). The resulting busbar cost would be one-fifth less than that of either a coal-fired steam plant with flue gas desulfurization or combined cycle plant fired by coal gas derived from a Texaco gasifier. The Lurgi/ISTIG technology would offer the environmental benefits of coal gasification in a power plant one-fifth as large as a commercial-scale version of the technology demonstrated at Cool Water, thus bringing to coal-based power technology the advantages of small-scale units.

The Lurgi gasifier is a proven, commercially available system. ISTIG is not commercially available, but it involves no technological proof-of-concept. The unproven part of the proposed system is the hot-gas clean-up, which would involve the use of iron and zinc oxide catalysts to remove the sulfur from the gases exiting the gasifier (in the form of H_2S and COS) before these gases are delivered to the combustor. The proposed sulfur removal technology has been

proven technically in bench and pilot scale investigations, and significant progress is being made in this area. Nevertheless, field experience is needed to demonstrate the long-term performance of the catalysts involved [8].

The attractiveness of the CIG/ISTIG concept led the U.S. Department of Energy to select for funding a pilot/demonstration project proposed by General Electric to develop essential features of this technology under the Department's Clean Coal Technology Demonstration Program. The \$156 million project was to include testing the hot-gas cleanup concept at an existing General Electric gasifier test facility, followed by the construction of a 5 MW pilot plant and a 50 MW commercial demonstration project based on the use of a STIG unit (CIG/STIG technology). (Under the Clean Coal Technology Demonstration Program the government provides half the total support, the private sector the other half.) In the fall of 1987, however, the pilot and commercial demonstration phases of the project were canceled, because the required private-sector support was not secured.

At present other significant efforts are under way to improve the overall economics of gas turbine-based power systems fired with gas derived from coal. Most notably, the Appalachian Project, a U.S. DOE-supported commercial demonstration, involving the use of an air-blown KRW fluidized bed gasifier, hot-gas cleanup, and a 63.5 MW combined cycle power plant, is moving ahead. With the collapse of the CIG/STIG project, however, there is no ongoing coal gasification/gas turbine project underway to exploit the advantages of aeroderivative gas turbine technology, even though a recent U.S. Department of Energy (DOE) analysis that systematically compared an airblown, pressurized fluidized bed gasifier/ISTIG unit with various combined cycle-based systems concluded that the ISTIG-based system would be the least costly [9].

Biomass-Gas Firing

Coal is not the only low-quality fuel that can be used to fire gas turbines for power generation. Biomass (green plant matter) is another possibility. There are several reasons why biomass-firing may prove to be more significant than coal-firing:

First, in light of the growing concern about the greenhouse problem, biomass energy sources have strong appeal, as the use of biomass fuel can help cope with the greenhouse problem three ways:

- o There is no net buildup of carbon dioxide in the atmosphere from the combustion of biomass, if biomass is produced and used renewably. Thus biomass grown renewably and substituted for fossil fuel would lead to a net reduction in fossil fuel-derived carbon dioxide emissions to the atmosphere.
- o The steady-state inventory of biomass associated with the renewable production and use of biomass will sequester significant quantities of carbon, if the biomass involved is wood from fast-growing but long-lived trees grown on plantations. The result can be an extraction of carbon dioxide from the atmosphere associated with past carbon dioxide emissions.

- o In developing countries where deforestation is a major problem, efforts to modernize biomass as an energy source would provide a major incentive for curbing deforestation, thereby leading to a reduction in carbon dioxide emissions associated with deforestation. This is possible because (i) the facilities required to modernize biomass as an energy source are capital-intensive, (ii) it is costly to transport biomass long distances, and (iii) the capital cost of the associated plantations would be a tiny fraction of the cost of the bioenergy conversion facility. Thus businesses involved in modernizing biomass as an energy source would be powerfully motivated to ensure the adequacy of locally produced biomass supplies throughout the lifetime (of the order of 30 years) of the bioenergy conversion facility.

Second, for developing countries modern bioenergy strategies are among the most promising energy strategies for promoting sustainable development:

- o With the exception of China, most developing countries have negligible coal resources, but many have significant biomass resources. Biomass already accounts for more than 40% of total energy use in developing countries, mainly in the form of firewood and crop residues used in the domestic sector for cooking. Though widely used at present, biomass is used so inefficiently that little useful energy is obtained. One indicator of this inefficiency is that per capita energy use for cooking is several times as large with fuelwood in rural areas in developing countries as with gaseous or liquid fuels in either developing or industrial countries (Figure 8) and is comparable to per capita energy use for automobiles in Western Europe in the mid-1970s! If bioenergy were modernized, much more useful energy could be extracted from biomass than at present, so that even without increasing primary bioenergy supplies, this energy source could play a significant role in the development of developing countries.
- o Because bioenergy systems are inherently labor-intensive, emphasis on bioenergy would provide direct opportunities for rural employment in developing countries. Emphasis on bioenergy could provide indirect rural employment opportunities as well, by providing energy for rural industrialization. Thus, both directly and indirectly the modernization of bioenergy can help stem unsustainable urban migration.
- o Because advanced biomass gasification/gas turbine power generating technologies hold forth the promise of being much less capital-intensive than conventional power generating technologies, this approach to electricity generation would be one effective way of coping with the electricity capital crisis facing developing countries.

Third, while biomass is usually not regarded as a major energy source for industrialized countries, modern technology can change this outlook, especially for the power sector. In the U.S:

- o Use of existing unused wood resources or wood grown on plantations in advanced biomass gasification/gas turbine power generating systems holds

forth the promise of electricity that is competitive with and less polluting than that from new coal power plants.

- o Growing wood on plantations for electricity generation would be a major new industry for the American farmer.
- o To the extent that these plantations are concentrated on highly erodable U.S. cropland they would provide an effective strategy for stabilizing the soils on these lands that are now being rapidly degraded.

In order to make bioenergy interesting for electricity generation and globally significant as a strategy for coping with the greenhouse problem, one needs an electric generating device that offers high efficiency and low capital cost at modest scales ranging from tens of kilowatts to about 100 MW. This scale limitation is dictated by the dispersed nature of the biomass supplies, which must be gathered from the countryside and transported to the power plant. If bioelectric plants were as large as 500 to 1000 MW, which is typical for coal and nuclear power stations, the cost of delivering fuel to the plant would be prohibitive. Traditional steam-electric power generating technology does not satisfy this criterion, because the capital cost is strongly scale-dependent--which is the main reason fossil and nuclear steam-electric plants are built big. But gas turbines and especially aeroderivative gas turbines do offer high efficiency and low unit capital costs at the modest scales required for bioenergy systems.

Moreover, the advances that have been made toward marrying aeroderivative turbine technology to coal (via CIG/STIG and CIG/ISTIG technologies) are readily transferable to biomass. With modest incremental R&D efforts this and similar emerging coal gasification/ gas turbine technologies could be adapted to biomass. Indeed, biomass gasification/gas turbine technologies could be commercialized more quickly than coal gasification/gas turbine technologies, since biomass is inherently easier to gasify than coal, and since biomass contains negligible quantities of sulfur, the cost-effective removal of which is the major technological challenge in ongoing coal gasification/gas turbine development efforts. The fact that sulfur cleanup technology would generally not be needed with biomass implies that the biomass-fired integrated gasification/intercooled steam-injected gas turbine system [BIG/ISTIG, the biomass version of CIG/ISTIG] would be about 1/5 less costly per kW (compare Table 6 and Table 5).

Biomass-Gas Turbine Applications in Developing Countries: Biomass-based power generation will probably be initiated in applications where biomass feedstocks are readily available as residues of food- or fiber-processing facilities. Significant fractions of these wastes are already being used for other purposes, so that one might think that the potential offered by wastes for new energy applications is quite limited. However, even wastes now fully utilized might be more effectively utilized in modern bioenergy systems.

Consider first the cane sugar industry, a major industry in many developing countries. With support from the Office of Energy of the U.S. Agency for International Development (US AID) our research group at Princeton, in collaboration with engineers at the Sugar Industry Research Institute of

Jamaica, has assessed the prospects for BIG/STIG (*) cogeneration technology, using the residues of sugar cane production and processing (**) as fuel. We found that, while cane residues are now used as fuel at sugar factories, these residues are used extremely inefficiently, and it would be cost-effective to adopt steam-conserving retrofits and install BIG/STIG cogeneration units. So doing would increase electricity production at the factories from the present typical level of 20 kWh per tonne of cane (using existing, inefficient steam turbines), the amount needed to run the factory, to about 460 kWh per tonne of cane--making it possible for sugar factories to become major exporters of electricity to the electric utilities. We found that the electricity produced this way would typically be less costly than electricity from new conventional central station power plants. For the 70 sugar-producing developing countries we estimated that the total electricity production potential at the present level of cane production is about 50 GW, or 1/4 as much as all the utility-generated electricity in these countries at present [10].

With continuing support from the Office of Energy of the U.S. Agency for International Development we are now extending this analysis of the cane sugar industry to the sugar cane-based alcohol industry, taking into account BIG/ISTIG as well as BIG/STIG technologies for this industry. We are exploring the extent to which the coproduction of electricity and alcohol can be used to improve the economics of alcohol production. Our analysis is showing that for each liter of alcohol produced the BIG/ISTIG unit would be able to produce more than 11 kWh of electricity in excess of the distillery's needs (about 820 kWh per tonne of cane). So much electricity would be generated that an alcohol/electricity coproduction facility would produce electricity as the primary product and alcohol as a byproduct.

The production of fuel alcohol from sugar cane is now well established in Brazil, with smaller alcohol industries in several other countries. While the alcohol produced this way was competitive with gasoline at the high oil price levels of the early 1980s, this is no longer the case. However, if alcohol and BIG/ISTIG-derived electricity were coproducts of sugar cane the result would be competitive alcohol, even at today's depressed world oil price.

To show how the economics of alcohol production might be improved through coproduction, consider the situation where the distiller sells the residues of sugar cane production and processing as fuel to a utility operating a BIG/ISTIG unit, charging a price for these residues what the market will bear--the cost

* Based on STIG (commercially available for natural gas firing) rather than ISTIG (still under development), BIG/STIG, though less efficient and more costly than BIG/ISTIG, will probably be commercialized first--perhaps at the same time that ISTIG is being commercialized for natural gas applications. Subsequently, the two new technologies could be combined as BIG/ISTIG.

** Barbojo, the tops and leaves of the sugar cane plant (typically burned off the cane just prior to harvesting in most parts of the world) and bagasse, the residue left after sugar cane is crushed and the sugar juice extracted.

(for transport, storage, and processing) plus a "rent" (Tables 7 and 8). And suppose the distiller buys from this utility all the steam and electricity needed to run the distillery. With zero rent the cost of producing alcohol is about 20 cents per liter, equivalent to gasoline @ \$1.10 per US gallon--too high to be economic at the present world oil price. But with zero rent the cost of electricity would be extraordinarily low--only 2.8 cents per kWh. Since the residue quantity is so large, a relatively modest fuel rent can lead to a major reduction in the selling price of alcohol, before driving up the price of electricity to noncompetitive levels. The effect of alternative levels of rent is shown in Table 9. Note, for example, that the credit from a rent that would reduce the net cost of alcohol in half would increase the cost of electricity to only 3.7 cents per kWh, which would still be competitive with the cost of electricity from most other sources. For example, hydroelectricity would be able to provide electricity more competitively only if the capital cost were less than about \$1300 per kW (Table 9). In Brazil, where new hydroelectric resources are located in Amazon regions that are remote from the major electricity markets in the Southeast, the capital costs for new hydro supplies (generation plus long-distance transmission) are typically higher than this.

The sugar cane-based sugar and alcohol industries thus represent good initial markets for BIG/STIG and BIG/ISTIG technologies. Once established in these markets the technology could be applied to other residues (e.g., residues of the forest products industry or even urban refuse) and eventually to bioenergy plantation feedstocks.

The Bioenergy/Energy Efficiency Connection: How much of a role could BIG/ISTIG play in providing the electricity required for development? The answer to this question depends on the attention given to end-use efficiency, because high levels of bioenergy development are limited by land-use constraints, owing to the low efficiency of photosynthesis. However, with emphasis on energy end-use efficiency, BIG/ISTIG technology could play a major role in the development process over the next several decades, even without major expansions in primary bioenergy supplies.

In ENERGY FOR A SUSTAINABLE WORLD my colleagues and I show that a living standard in developing countries up to that of Western Europe in 1975 could be achieved with an average rate of final energy use of 1 kW per capita, only slightly more than the developing country average in 1980 of 0.9 kW, if emphasis is given to (a) improved efficiency of energy use and (b) modern energy carriers (*).

To what extent could the coproduction of alcohol and electricity at cane sugar-based alcohol distilleries be exploited in providing such a living standard in an energy-efficient, sugar cane-growing developing country before running up against land use constraints? As cane plantations can produce about 55 tonnes of cane per hectare per year, net exportable energy would amount to

* One key feature of this "1 kW scenario" is emphasis on electricity. Electricity production per capita would have to increase from the 1980 developing country average of 400 kWh, to 2100 kWh per capita, about half of the actual average for Western Europe in 1975 (Table 10).

45,100 kWh of electricity and (@ 73 liters per tonne of cane) 4015 liters of ethanol per hectare per year. Thus since the energy-efficient "1 kW scenario" described in ENERGY FOR A SUSTAINABLE WORLD requires about 2100 kWh/year per capita for electricity and the energy equivalent of 365 liters/year of alcohol for fluid transport fuel, it is seen that 1 hectare of sugar cane could provide these electricity requirements for 21 people and the transport fuel requirements for 11 people, on average. Or, put another way, the amount of land needed for sugar cane to provide all the electricity plus half the transport fuel required to support a Western-European living standard in an energy efficient society would be less than 0.05 hectares per capita, or less than 25% of the amount of land required to provide all food using modern agricultural practices (about 0.20 hectares per capita).

Biomass-Gas Turbine Applications in the US: The favorable economics of BIG/ISTIG as a power generating technology, the large biomass resource base in the US, and concerns about local and regional air pollution and global warming are all reasons why serious consideration should be given to BIG/ISTIG applications in the US.

Consideration might be given to building BIG/ISTIG plants instead of new coal plants or to replacing existing coal plants, when they are to be retired, with BIG/ISTIG plants. Such replacements could have a major impact on carbon dioxide emissions, as 85% of the carbon dioxide emissions from the power sector and 28% of all U.S. carbon dioxide emissions come from coal-fired power plants (Table 11). Replacing coal with biomass this way would also offer major benefits as part of a broad effort to cope with the problem of acid rain, as emissions of sulfur dioxide and oxides of nitrogen would tend to be low for BIG/ISTIG power plants.

Would U.S. biomass supplies be large enough to have much of an impact? One possible source of biomass supplies would be presently unused wood supplies, such as the excess growing stock and mortality of commercial forests, logging and wood processing residues, urban wood removals, etc. (Table 12). At present these wood supplies amount to 10.9 Exajoules (10.3 Quadrillion BTU), or about 13% of total primary energy use in the United States. If all of of this wood were committed to BIG/ISTIG-based power generation there would be enough to displace about 5/6 of all coal-based power generation at present. Some of these supplies would be quite competitive sources of biomass fuel--especially the residues from the processing of forest products. Logging residues could also become competitive if they were recovered at the same time as the commercial timber involved. Harvesting the large excess growing stock and mortality on existing commercial forestlands might be economical where the wood densities (tonnes/hectare) are reasonably high and the resources reasonably close to markets.

An alternative source of biomass supply would involve growing biomass on energy plantations, using fast-growing, short-rotation trees such as hybrid poplar, black locust, sycamore, black cottonwood, and eucalyptus. The Department of Energy's Short Rotation Woody Crops Program has made major strides over the last decade, increasing productivities for short-rotation intensive culture (SRIC) from 9 to 13 tonnes per hectare per year and reducing the average cost of dry wood chips delivered to the user from \$5.3 to \$4.0 per

GJ (average for five well-documented research sites, with one coppice cut), between 1978 and 1987 (*).

If natural gas-fired ISTIG and BIG/STIG technologies were demonstrated at the same time, BIG/ISTIG technology could be commercially available by the mid-1990s--probably several years in advance of the commercial availability of CIG/ISTIG technology, in light of the fact that chemical hot gas cleanup technology is required for the latter but not the former. Because of its low capital cost and high efficiency, BIG/ISTIG technology could compete with conventional coal-fired steam-electric power generation in the U.S. in this time frame, even if the price of biomass were much higher than the price of coal, on an energy-equivalent basis. For a utility coal price of \$50 per metric tonne (\$1.76/GJ, the average U.S. price projected for 2000 by the U.S. Department of Energy), BIG/ISTIG would be competitive up to a price of biomass delivered to the power plant in suitable form (e.g., chipped and dried enough to be suitable for gasification) that is 2.2 times as large in energy terms (see note b, Table 13). Even with the present embryonic state of SRIC technology there are likely to be significant biomass supplies available at such prices, and BIG/ISTIG-based electricity generated with biomass grown on such plantations would be roughly competitive with electricity generated with coal in conventional steam-electric power stations in the Pacific Northwest, South Florida, and the Northeast, and nearly competitive in the Great Plains region (compare Tables 13 and 17).

If hot gas cleanup technology is successfully demonstrated, BIG/ISTIG would eventually have to compete with CIG/ISTIG as well as with conventional coal-fired, steam-electric power systems. However, on a per unit energy basis biomass would still enjoy a cost advantage in relation to coal (see note b, Table 13). Moreover, with expected future cost reduction and productivity improvement the prospects are good for making BIG/ISTIG power roughly competitive with CIG/ISTIG power and strongly competitive with coal-based, steam-electric power in a wide range of applications by the turn of the century (see Tables 13 and 17). This prospect would of course be enhanced by government initiatives to tax carbon emissions from fossil fuels and adequate R&D support for SRIC.

If SRIC plantations were to be established on farmland, emphasis might be given to highly erodable farmland. In the U.S. 48 million hectares (118 million acres) is generally regarded as highly erodable, and 34 million hectares (83 million acres) is characterized by an erodability index of 8 or more (Table 18). [For comparison the total amount of U.S. cropland is 190 million hectares (469 million acres).] Concern about this problem led to the Conservation Reserve Program (CRP), created under the Food Security Act of 1985, which put a 10 year moratorium on harvesting from conservation land included in this program. Under the CRP farmers offer to convert targeted cropland to non-crop vegetative uses in exchange for an annual government payment. The Food Security Act of 1985 targeted putting 16-18 million hectares

* J. Warren Ranney, Lynn L. Wright, and Patricia A. Layton, "Hardwood Energy Crops: the Technology of Intensive Culture," *Journal of Forestry*, vol. 85, no. 9, September 1987.

(40-45 million acres) into the CRP by 1990, and Senate Bill S.1521 (introduced July 22, 1987) sought to extend program coverage to 26 million hectares (65 million acres) by 1990.

Putting such erodable land into SRIC plantations characterized by rotations of 6-10 years or more [and perhaps 3 coppices (harvests) per planting] would be a good way to promote soil conservation while simultaneously generating significant income for the farmer. SRIC analysts point out that after the first year, the root systems, litter formation, and canopy stabilize and protect soils very well (*).

Using ISTIG to Help with Acid Rain, and Ozone Pollution

Advanced aeroderivative gas turbines offer major advantages with regard to local, regional, and global air pollution problems, while simultaneously being able to provide electricity at lower cost than is possible with conventional electric generating technologies [6].

Acid Rain Control: If CIG/ISTIG were commercially available, the scrapping of existing coal-fired steam-electric plants in favor of new CIG/ISTIG plants erected at the same sites would be a cost-effective alternative to installing scrubbers on these plants. Allocating all the incremental costs of CIG/ISTIG to sulfur removal would lead to an acid rain control cost \$400 per tonne, compared to a scrubber cost of between \$340 and \$640 per tonne (Figure 9). Despite its much higher capital cost, CIG/ISTIG, would be able to compete with scrubbers as an acid rain control strategy because coal requirements per kWh of electricity produced would be 1/4 less than for steam-electric plants retrofitted with scrubbers.

While CIG/ISTIG will probably not be commercially available until near the turn of the century, natural gas-fired ISTIG plants could be available in 4 years, so that an alternative acid rain control strategy would be to replace existing coal plants with natural gas-fired ISTIG units for perhaps the first 20 years of operation, to be converted thereafter to coal- or biomass-fired CIG/ISTIG or BIG/ISTIG units. The cost of acid rain control with this strategy would be \$330 per tonne and \$640 per tonne, for natural gas prices of \$3 per GJ and \$4 per GJ, respectively [6]--prices that are, respectively 50% and 100% higher than the US average price of gas for utilities in 1987.

Reducing Carbon Dioxide Emissions: Accounting for 1/3 of total US CO₂ emissions (Table 11), the electric utility sector is a good target for supply-side initiatives to reduce CO₂ emissions. ISTIG technology could help reduce CO₂ emissions, as coal-fired, natural gas-fired, and biomass-fired (*) versions² would emit only 0.8, 0.4, and 0.0 times as much CO₂ per kWh as new conventional coal steam-electric power plants.

The ISTIG-based acid rain control strategy described above is one way to use ISTIG technology to reduce carbon dioxide emissions. If 10 million tonnes per year of SO₂ were removed by shifting from coal-fired steam-electric plants

* For biomass produced on a renewable basis.

(with an average sulfur content of 3.1% in the displaced coal) to natural gas-fired ISTIG units, some 414 TWh of electricity production would be shifted from coal (fuel input of 4.5 EJ/year) to natural gas (fuel input of 3.2 EJ/year). The corresponding reduction in carbon emissions (as CO₂) would be 68 teragrams per year (equivalent to 4.9% of total US CO₂ emissions in 1987).

The shift by the year 2000 of some 260 TWh of power generation from existing natural gas-fired steam-electric plants to ISTIG described above would reduce US carbon dioxide emissions some 13 Teragrams per year (0.9% of total US CO₂ emissions in 1987) while saving 0.95 EJ per year of natural gas and reducing the cost of electricity in the process.

Sometime after the turn of the century, if the price of natural gas gets too high, ISTIG units could be converted to coal or to biomass firing. If 1/3 of the natural gas-fired ISTIG units were shifted to coal and 2/3 to biomass, the average rate of carbon dioxide emissions per kWh would be 0.27 times as much as with conventional coal-fired steam-electric power plants or 1/3 less than with natural gas. Thus aggregate CO₂ emissions would be reduced by an additional 23 teragrams per year (equivalent to 1.7% of total US CO₂ emissions in 1987).

BIG/ISTIG systems might be fired with wood chips derived from trees grown on plantations on highly erodable cropland, as discussed above. Shifting 2/3 of natural gas-fired ISTIG units to BIG/ISTIG would require 3.9 EJ of wood fuel. For an average yield of 10 dry tonnes per hectare per year [which is achievable with present technology (Table 17)] some 19 million hectares would be required. If the trees had a rotation length of 15 years, the steady state biomass inventory on 19 million hectares of plantations would also sequester 665 teragrams of carbon, equivalent to nearly 1/2 of total annual US CO₂ emissions.

Still another element in an ISTIG greenhouse strategy could involve replacing the remaining existing coal-fired steam-electric plants in favor of coal-fired ISTIG units on retirement (which might be completed over the next 30 years). As total coal-fired power generation in 1987 was 1464 TWh, some 1050 TWh/year of coal-based power generation would be left for conversion after implementing the acid rain control strategy articulated above. As CIG/ISTIG plants would emit 0.79 times as much CO₂ as existing coal steam-electric power plants, the result would be a reduction of 59 teragrams per year of carbon emissions as CO₂ (equivalent to 4.2% of total US CO₂ emissions in 1987).

The four parts of this greenhouse control strategy would thus lead to an annual reduction of carbon emissions of:

$$68 + 13 + 23 + 59 = 163 \text{ teragrams/year (11.7\% of total US emissions in 1987),}$$

plus the sequestering of 665 teragrams of carbon in the biomass plantations.

Reducing Ozone Pollution: One of the most promising areas for commercializing ISTIG technology is in southern California, where the South Coast Air Quality Management District has proposed tough new NO_x emissions standards for existing gas-fired steam-electric power plants as part of a general strategy for

bringing the South Coast Basin into compliance with ambient air quality standards established under the Clean Air Act. As part of this effort, proposed Rule 1135 would require that NO_x emissions from existing electric power generating steam boilers be reduced to no more than 0.03 lb per MBTU of heat input by July 1992 (Appendix B). At present emissions average 0.1 lb per MBTU (and range from 0.034 to 0.71 lb per MBTU). Control on existing units would require the installation of selective catalytic reduction (SCR) units, estimated by the engineering staff at the Southern California Edison Company to cost, on average, \$128 per kW [11].

The staff of the California Energy Commission has recommended that the Southern California Edison Company scrap 5700 MW of existing steam-electric capacity in favor of new ISTIG plants, for which NO_x control is automatic (*), as an alternative to installing SCR on the existing units (Appendix B). Even though the ISTIG option would involve a 3-fold increase in the capital cost (\$400 vs. \$128 per kW), the fuel savings of 1/3 that would be realized with the ISTIG alternative would make the ISTIG option overwhelmingly more cost-effective. At a 42% capacity factor the lifecycle breakeven gas price would be \$2.2/GJ, and achieving breakeven in the very first year would require a gas price of only \$2.8/GJ (Table 20). Thus, if the proposed NO_x control rule is adopted and is made flexible enough to allow this "scrap and build" alternative control strategy, a very powerful mechanism could come into play to help force the commercialization of ISTIG.

Roles for the Public Sector Relating to Advanced Aeroderivative Turbines

The US is already witnessing widespread interest in advanced gas turbines in both cogeneration and central station power markets. To date most of this interest is focussed on heavy-duty industrial turbines and combined cycles. While both heavy-duty industrial and aeroderivative turbines have important roles to play in power generation, I have argued here that there are many reasons for fostering a more balanced mix between heavy-duty industrial turbines and aeroderivative turbines in power markets. The public sector could play important roles in helping bring this about.

I was pleased to see that in Section 1007 of S. 324, provision is made for research, development, and demonstration on advanced natural gas-fired gas turbine cycles, including ISTIG. I would like to emphasize, however, that ISTIG could be just the first of a continuing stream of high-efficiency, low-polluting, cycles that can come from the exploitation of the advances that are being made in aircraft engine technology. For example, analysts at the Pacific Gas and Electric Company, the General Electric Company, and the California Energy Commission are already thinking about a second-generation ISTIG technology, the so-called chemically recuperated, intercooled, steam-injected gas turbine, which would offer further efficiency improvements [6] and even lower NO_x emissions characteristics (Table 19). I hope the program that will be

* NO_x formation in natural gas-fired gas turbines takes place primarily as a consequence of the high peak flame temperatures in the primary combustion zone of the gas turbine combustor. Both steam injection and intercooling lead to lower peak flame temperatures and thus lower NO_x levels (Table 19).

developed from Section 1007 (should this legislation be adopted) will take this longer-term perspective.

While both GE and DOE analyses indicate that coal-fired ISTIG units would probably be the least costly of the clean coal technologies under consideration for marrying coal to the gas turbine, while the use of this technology appears to be one of the most promising of the clean coal technologies for reducing CO₂ emissions, and while developing this technology would help exploit the US lead² in aeroderivative turbine technology, there is currently no clean coal initiative underway or in the offing in this area. It would seem that the priorities in the Clean Coal Program should be reordered.

A commercial demonstration of BIG/STIG technology is also warranted, in light of the economic promise of this technology for both developing and industrialized country applications (*) and its potential importance in coping with the greenhouse warming problem. Even though STIG technology is commercially available for natural gas applications, and coal gasifiers suitable for use with biomass and well-matched to STIG units are commercially available, the combination needs to be proven in a commercial demonstration. This could probably be accomplished with \$40-\$50 million for the demonstration of a 20 MW BIG/STIG unit that would subsequently find many commercial opportunities without the further "scaling up" that is typically required with coal-based demonstrations.

The public sector can also help nurture the commercialization of this new class of gas turbines in ways other than by supporting commercial demonstrations. Introducing more competition in the power sector would be helpful. As shown here, the total cost of new natural gas-fired ISTIG units would be less than the operating cost of existing gas-fired steam-electric power plants in some circumstances today, and this will certainly be the case in many areas in the 1990s, at the higher natural gas prices expected then. Thus if independent power producers were allowed to compete with existing steam-electric capacity, they would probably do well, if equipped with technologies like ISTIG that offer impressive performance at modest scale. (A 114 MW ISTIG unit would cost just \$46 million.) Another helpful strategy would be to put tough regulatory constraints on existing utility plants for which life extension is requested, so as to accelerate the transition to more efficient and less polluting new plants. And finally, tightening air pollution regulations could be tailored to encourage technological innovation in power generation as a strategy for meeting environmental goals.

* In the long run, the making of liquid and gaseous fuels from biomass feedstocks will also be important. However, until the world oil price is much higher than at present it will be difficult to make biomass-derived liquid and gaseous fuels competitive. In contrast, as shown here, BIG/ISTIG technology would appear to be competitive in many electricity markets at present.

PHOTOVOLTAIC HYDROGEN

It has long been recognized that electrolytic production of hydrogen using photovoltaic (PV) electricity would have strong environmental advantages over fossil fuel-based energy supply options. The absence of carbon monoxide, volatile organic compounds, oxides of sulfur and other noxious pollutants in the production and combustion of hydrogen would help solve serious local and regional air pollution problems such as the deterioration of urban air quality and acid deposition on lakes and forests. Moreover, because no carbon dioxide is released in its production or combustion, a PV hydrogen system would not contribute to the global greenhouse warming.

While PV hydrogen production and utilization are technically feasible, economic assessments published in the early 1980s concluded that photovoltaic electricity would probably always be too expensive for PV hydrogen to be economically competitive with other synthetic fuels. A reconsideration of the PV hydrogen option is warranted for two reasons.

First, there has been rapid progress in the development of new thin-film amorphous silicon (a-Si) PV cells that require much less raw material and energy to manufacture and are amenable to inexpensive mass production techniques, suggesting that the DC electricity produced with such cells (and therefore PV hydrogen) could become much less costly than was previously thought possible.

Second, there is a growing awareness of the high environmental costs of continued dependence on carbon-based fossil fuels. Rising concern about the observed global warming from the greenhouse effect, the long-term effects of acid deposition, and poor urban air quality are providing new impetus to the development of low polluting, non-fossil energy sources.

Progress in Amorphous Silicon Solar Cell Technology

Before about 1980, the only commercially available solar cells were made of high-grade, single-crystal silicon, using a material and energy-intensive crystal growing process. In the early 1980s the industry began marketing solar cells made of polycrystalline silicon, a less expensive (but somewhat less efficient) material composed of many small crystallites. Also around 1980, the first thin film a-Si solar cells were introduced.

The cost of solar cells has dropped steadily, as new solar cell materials and improved manufacturing methods were developed. In the early 1970s solar cells were priced at over \$100 per peak Watt. At present, single crystalline cells cost perhaps \$5 per peak Watt to manufacture, polycrystalline cells \$3 per peak Watt and amorphous silicon about \$1.6 per peak Watt. While improvements in efficiency and manufacturing techniques may eventually reduce the production cost of crystalline and polycrystalline solar cells to \$1-2 per peak Watt, a-Si silicon technology appears to have the greatest potential for reaching the low solar cell costs needed to make PV hydrogen economically competitive with other fuels.

The a-Si solar cell is a very new technology. It was not until 1974

that it was discovered that thin films of amorphous silicon could be used to convert sunlight directly into electricity. Amorphous thin films are about 1 micron thick, using much less raw material than crystalline solar cells, which are typically 100-200 microns thick. In contrast to the crystal growing and cutting process, amorphous silicon solar cells are produced by vapor depositing silicon on an inexpensive substrate such as glass, plastic or stainless steel. Because of the speed with which vapor deposition can be done, the ease with which electrical connections can be made, and lower energy and material requirements, amorphous modules can be mass produced much more quickly and cheaply than crystalline modules [12].

Progress in amorphous silicon technology has been rapid. Efficiencies have increased from 1 percent for the first cells in 1976 to over 13 percent for small-area laboratory cells, to over 11 percent for larger area laboratory modules and to 5-7% for large-area, commercially available mass-produced modules in 1987 (Figure 10,top). Since the first commercial amorphous silicon solar cells were introduced in 1980, production has steadily increased, reaching 11.9 MW (or 41 percent of the total worldwide PV market) in 1987 (Figure 10,bottom).

The current production cost is estimated at \$1.5-\$1.6 per peak Watt for 6% efficient commercial modules, produced in batch operations in small facilities with production capacities of the order of 1 megawatt peak per year or less. In larger plants, considerable economies of scale could be realized. According to Dr. E. S. Sabisky (formerly, manager of the Amorphous Silicon Research Project, at the Solar Energy Research Institute):

"...if today's thin-film amorphous silicon modules of 6-8% efficiency are combined with a 10 megawatt annual production plant, the module cost target of \$1 per peak Watt can be reached..."

A cost breakdown for 6% efficient modules costing \$1.16 per peak Watt produced in a 10 MWp per year production plant proposed by Solarex is indicated in Table 21. What is remarkable about this disaggregation of costs is that only about 10% of the total cost is associated with the active materials used in the cell. Because these materials account for such a small fraction of the total cost, the cost per peak Watt is expected to vary roughly inversely with the efficiency, all other factors being equal.

What are the expected future efficiencies of a-Si solar cells? By the early to mid-1990s, efficiencies for commercial modules are expected to be 10% (for single-layered cells) and 13% (for multi-layer cells). By the year 2000, commercial modules approaching the "practical limit" values of 12-14% for single layer solar cells and 18-20% for multi-layer cells may well become available, according to a-Si industry projections [12].

Starting with a detailed design for 6% cells that could be produced today in a 10 MWp per year production facility (Table 21), David Carlson of Solarex has estimated what the impacts on production costs would be of a 10-fold increase in the production volume (in square meters per year), a doubling of cell efficiency, the integration of the a-Si plant with a float glass plant, a doubling of the plant depreciation period (from 5 to 10 years, reflecting the

maturing of the technology), and the exploitation of other (minor) opportunities for reducing materials costs [12]. This analysis indicates that 12% efficient modules would cost about \$0.25 per peak Watt (Table 22). Extending Carlson's analysis to 18% efficient modules would reduce costs further, to \$0.16 per peak Watt (Table 22).

Such cost projections, if realized, indicate that a-Si solar cells are promising not just for electricity generation, but perhaps also for the production of hydrogen. The conversion to hydrogen provides not only a clean source of energy but also a convenient way to store solar energy for when the sun is not shining, and a much lower cost energy carrier than electricity for transporting solar energy to markets that are remote from the sunny areas where the best conditions for solar energy conversion are.

Design of an a-Si Photovoltaic Electrolytic Hydrogen System

To explore the possibilities for making hydrogen via electrolysis using amorphous silicon solar cells my colleague Joan Ogden and I have carried out a detailed design and cost analysis of a PV hydrogen system [13].

The purpose of our study was to explore the implications for PV hydrogen if PV industry performance and cost goals are met in the time frame near the turn of the century. The point of departure for our analysis is assumed module efficiencies of 12 to 18% (corresponding to PV system efficiencies of 10% to 15%) and corresponding module costs of \$0.40 to \$0.20 per peak Watt. Other assumptions relating to our analysis are summarized in Table 23 and discussed extensively elsewhere [13].

Figure 11 is a sketch of a PV hydrogen system based on amorphous silicon solar cells. DC electricity produced in a PV array would power an electrolyzer, which would split water into hydrogen and oxygen. Hydrogen would be compressed, if necessary, for onsite use, storage or pipeline transmission.

Because at least 50% of the cost of PV hydrogen is due to the cost of DC electricity, it would be less expensive to locate a large PV hydrogen energy system in a sunny location, and transport hydrogen to distant users via high pressure pipelines. In our study, we assumed that the PV system is located in the Southwestern US.

The Cost of PV Electricity: We estimate that the production cost of DC electricity from an amorphous silicon solar array located in El Paso, Texas, would be \$0.02/kWh for 18% efficient modules costing \$0.20 per peak Watt or \$0.035 per kWh for 12% efficient modules costing \$0.40 per peak Watt.

The Cost of PV Hydrogen : For DC electricity costing \$0.020-0.035/kWh, PV hydrogen would cost \$9.1-14/GJ to produce (Table 24). For a large-scale hydrogen energy system, the corresponding total cost of PV hydrogen at the end of a 1000 mile pipeline would be \$10.8-\$16/GJ (Table 25).

Comparison with Other Synthetic Fuels: Table 24 shows that the cost of PV hydrogen would probably be less than the cost of electrolytic hydrogen from other sources, including nuclear. At the present nuclear capital cost of

about \$3000 per kW, nuclear hydrogen would cost about \$24 per GJ; if the nuclear industry target cost of \$1600 for "born-again" nuclear power could be reached, the cost of nuclear hydrogen would still be \$14 per GJ, at the high end of the PV hydrogen cost estimates.

Table 26 shows the cost of PV hydrogen compared to synthetic liquids and gases from coal and biomass. We found that PV hydrogen would be approximately competitive with synthetic liquids from coal or biomass (projected to cost \$8-16/GJ), but probably more expensive than synthetic gases from coal (projected to cost \$4-10/GJ).

Economies of Scale: Because PV arrays and electrolyzers are modular technologies, it would be possible to achieve low production costs in very small facilities. There are essentially no economies of scale for electrolyzers larger than about 2 MW and for PV systems larger than 5-10 MW. Thus PV hydrogen systems could be highly modularized, with typical module capacity in the range 5-10 MW and characteristic capital costs of several million dollars. This contrasts with coal-based synfuels, where billion dollar plants would be needed to exploit economies of scale.

Water and Land Use: PV hydrogen could be produced even in very arid regions. In El Paso, Texas, for example, where the insolation is high but precipitation very light [with annual rainfall amounting to only 20 centimeters (8 inches)], the feed-water required for electrolysis would be only 12 to 17 percent of the average precipitation falling on an area equivalent to the solar collector area.

PV hydrogen production capacity could be concentrated in relatively small areas. Producing hydrogen equivalent to total US oil use would require a collector field in the Southwest of some 64 thousand square kilometers (24 thousand square miles). This is equivalent to 0.5% of total US land use or about 7% of the desert area in the US. Figure 12 shows the areas required to produce hydrogen equivalent to all oil, all oil and gas, and all fossil fuel use in the US in a single circular collector field located in the Southwest.

For comparison, the amount of land required to produce synthetic liquid fuels equivalent to current US oil use from the estimated 86 billion tonnes of strip-minable coal reserves would average about 22 thousand square kilometers, and from biomass about 1790 thousand square kilometers. Thus photovoltaic hydrogen production would require 3 times as much land use as production of coal-based synthetic fuels, but only about 1/30th as much land use as would be required for the production of synthetic fuels from biomass.

PV Hydrogen as a Transportation Fuel

If goals for amorphous silicon solar cells are achieved, PV hydrogen could become comparable in cost to other liquid synthetic fuels (Table 26). This suggests that the first large market for PV hydrogen might be as a transportation fuel. Moreover, automotive manufacturers in Germany and Japan have ongoing programs to develop hydrogen-powered cars, making it likely that hydrogen-based transport technology could be commercialized by the early 21st century.

Hydrogen-Powered Cars : The Storage Challenge and Energy-Efficient Cars: Because of hydrogen's low volumetric energy density, storing enough fuel onboard for a long travelling range is a major challenge. For automobiles with fuel economy of 30 miles per gallon of gasoline-equivalent (mpg), this suggests that hydrogen-fueled cars would be short-range vehicles and would probably use liquid hydrogen. However, liquid hydrogen fuel would be more considerably more expensive than gaseous hydrogen, because of the high cost of liquefaction which could add \$6-10/GJ to the fuel cost [13].

An alternative approach is to increase the fuel economy of the vehicle, so that less fuel is needed to attain a reasonable travelling range. As indicated above, it is now technically feasible to improve automotive fuel economy to the range 80 to 100 mpg of gasoline-equivalent fuel. With high fuel economies limited range would not be a serious constraint on the use of compressed hydrogen gas or metal hydride storage. In our study, we assumed that a metal hydride would be used to store hydrogen in cars.

The Economics of Cars Fueled with PV Hydrogen and Other Fuels: Figure 13 shows the lifecycle cost per kilometer of owning and operating a car powered by gasoline (costing \$1 per gallon), methanol from coal, synthetic natural gas from coal, electric batteries, and PV hydrogen for a range of delivered fuel prices and for three levels of fuel economy (corresponding approximately to 30, 50 and 90 mpg of gasoline-equivalent, respectively). We find that fuel costs are a relatively small part of the total cost (less than 25% at 30 mpg and less than 10% at 90 mpg). Moreover, there is little difference among fuels in the total lifecycle cost of owning and operating a car. The consumer would pay about the same for a low-polluting, PV hydrogen-powered car, as for one fuelled with synthetic fuels from coal or electricity from coal or nuclear. And, for highly efficient cars, a travelling range of 400 km could be achieved with all fuels except electricity, where battery weight and bulk would limit range to about 170 km, even with advanced batteries and efficiency improvements.

A Possible Path for Commercialization of PV Hydrogen

If performance and cost goals for a-Si solar cells are met, PV hydrogen produced in the Southwestern US could become cost competitive with other transport fuels from coal or biomass around the year 2000. While economics alone would not compel a switch from gasoline to PV hydrogen-powered transport, environmental considerations might provide an early impetus for developing PV hydrogen as a transport fuel.

As an example of how a local PV hydrogen transport system might develop, we considered the city of Phoenix, Arizona. Located in a sunny area, Phoenix is ideal for PV hydrogen production and has a severe and growing air pollution problem. In 1987, levels of ozone, carbon monoxide and particulates in Phoenix exceeded federal health standards 33 days out of 365. The majority of this pollution is due to automotive emissions. Over the next 30 years the population is expected to increase from 2 to 5 million people, and without controls on automotive emissions, air pollution from cars could triple.

Much tougher automotive emissions standards are needed to prevent further

deterioration of and to improve urban air quality. In the near term, implementing proposed new emissions standards could cut pollution in half by 2000. But the introduction of hydrogen-powered vehicles could also have a small, but significant, near-term impact.

Getting Started with Hydrogen Produced with Off-Peak Power from Conventional Power Plants to Get Started: Since PV hydrogen is not likely to be sufficiently low in cost to introduce before the turn of the century, one way to initiate a transition to a hydrogen economy in the 1990s would be to use offpeak power from conventional power plants to provide hydrogen for fleet vehicles. We examined a scenario in which half of all fleet cars (4% of all cars but accounting for 10% of all car miles travelled) are operated on hydrogen derived from this offpeak power by the year 2000. After the year 2000 PV hydrogen would start to be introduced, so that by 2015 half of all cars in Phoenix would be operating on hydrogen. In this scenario automotive emissions would fall to half the present level by 2000 and would still be below present levels by 2015, despite a projected three-fold increase in the number of vehicle-miles traveled.

Targetting Fleet Vehicles: Fleets would have the oft-mentioned advantage that they could be centrally fuelled and maintained, which would minimize the initial investment in a fuel distribution system. The first hydrogen fleets might belong to utilities, which would probably have some experience with PV systems, or to city or state governments. Because PV hydrogen systems would have little economy of scale above sizes of perhaps 5-10 MW, the initial investments in PV hydrogen systems could be small. More capacity could be added in modest increments, as the demand increased.

Beyond Fleets: Once the technology was established for fleets, local utilities could begin to offer hydrogen fuel for private automobiles. In order to interest consumers, it would be important to have multi-fuel capable vehicles, which could use other fuels in areas where hydrogen was not yet available.

If local hydrogen transport systems were successful in reducing air pollution levels in the Southwest, cities in the Northeast and the Midwest might decide to convert to hydrogen as well. If just 10% of fleet vehicles in the US converted to hydrogen, there would be enough demand to justify building a pipeline to bring hydrogen from the Southwest to the Northeast. Hydrogen-powered transport might then follow a similar pattern in northern cities, first as a fuel for fleets and then for private vehicles.

Once pipelines were built and hydrogen was established as a transportation fuel, it might begin to find other uses as well. For example, hydrogen could be used for residential space and water heating in the Northeast, at a cost comparable to using synthetic natural gas from coal or electricity [13].

The Importance of Energy Efficiency: A switch to hydrogen would take many decades to complete. In the near term, reducing fossil fuel use through improved energy efficiency is important for both economic and environmental reasons. It is also a necessary step toward a transition to a hydrogen economy, as energy efficiency improvements can often lead to improved economics and improved consumer acceptance of PV hydrogen [13]. For the long term, PV hydrogen used in energy-efficient end-use technology could provide energy

services with very little air pollution and no CO₂ emissions at costs comparable to or lower than with coal or nuclear power.

Public Policy Issues

What should the role of the public sector be in promoting a transition to a hydrogen economy? Policies aimed at coping with externalities would be helpful--tough local air pollution standards, an oil tax or tariff designed to help curb imports, and a carbon tax or alternative measure for coping with the greenhouse problem would all be helpful.

Also a tough policy promoting energy efficiency now would greatly facilitate a transition to hydrogen in the period beyond 2000. As urban transportation appears to be the most promising initial market for PV hydrogen, the promotion of improved automotive fuel economy is crucial--i.e. targetting average fuel economies for new cars in the range 60 to 80 mpg or more in the first decade of the next century would be very helpful.

Another important issue is public policy relating to the taxation of energy. The costs of producing PV electricity and PV hydrogen are mostly capital costs. Consideration should be given to eliminating taxes that discriminate against capital-intensive energy sources in favor of alternatives. If governments need tax revenues from the energy industries in excess of what can be provided by oil and carbon taxes, the additional taxes should be designed so as not to discriminate against capital-intensive energy systems.

Increased R&D is warranted on thin-film PV technology to hasten the achievement of the PV performance and cost goals needed to make PV hydrogen economically interesting. And ways have to be found to keep our industry motivated to reach these goals. (It is a sad commentary on the US PV industry that ARCO is seeking a buyer for ARCO Solar, one of the world's leaders in thin-film PV technology, just as the costs of thin-film PV modules approach levels where they can begin to compete in peaking electric power markets.)

R&D on PV hydrogen system design and hydrogen end-use systems are also called for. While considerable research on hydrogen end-use technology was carried out in the US in the 1970s, little is being done today. This is in contrast to the situation in Germany, where Daimler Benz and BMW are developing hydrogen-powered cars and associated hydrogen storage systems, and there is ongoing research on residential use of hydrogen.

The emphasis on hydrogen in S. 324 is encouraging, although we would question the priorities set forth there. It appears to us that urban transport applications will be economically interesting long before air transport applications. Hydrogen would have to be liquefied for airplane use, and liquefaction is very costly. For decades it will be hard to offset this added cost with the fuel savings from the reduced fuel weight associated with a shift to hydrogen [13].

Finally, the conversion of some government fleet cars in Southwest cities to hydrogen produced with offpeak power from existing power plants would be an important way for government to initiate a transition to a PV hydrogen economy.

Table 1. Space Heat Requirements in Single Family Dwellings
(kJ per square meter per degree-day)^a

United States	
Average, housing stock	160
New (1980) construction	100
Mean measured value for 97 houses in Minnesota's Energy Efficient Housing Demonstration Program	51
Mean measured value for 9 houses built in Eugene, Oregon	48
Calculated value for a Northern Energy Home in New York City area ^b	15
Sweden	
Average, housing stock ^c	135
Homes built to conform to the 1975 Swedish Building Code ^d	65
Mean measured value for 39 houses built in Skane ^e	36
Measured value, house of Mats Wolgast ^f	18
Calculated value for alternative versions of the prefabricated house sold by Faluhus ^g	
Version No. 1	83
Version No. 2	17

Sources: For U.S. housing stock average: R.H. Williams, G.S. Dutt, and H.S. Geller, "Future Energy Savings in US Housing," *Annual Review of Energy* 8(1983): 269-332. For new U.S. construction and nine houses in Oregon: J.C. Ribot et al., "Monitored Low-Energy Houses in North America and Europe," in *What Works: Documenting Energy Conservation in Buildings*, J. Harris and C. Blumstein, eds., proceedings of the Second Summer Study on Energy Efficient Buildings (Washington, D.C.: American Council for an Energy Efficient Economy, 1983), 242-256.

- The required output of the space heating system per unit floor area per heating degree day (base 18° C).
- The Northern Energy Home (NEH) is a superinsulated home design based on modular construction techniques with factory-built wall and ceiling sections mounted on a post and beam frame. The energy performance was estimated using the CIRA computer program (personal communication from D. Macmillan of the American Council for an Energy Efficient Economy, Washington, D.C.). The house has 120 square meters of floor area, triple-glazed windows with night shutters, 20 centimeters (23 cm) of polystyrene insulation in the walls (ceiling), 0.15 air changes per hour (ACH) natural ventilation plus 0.35 ACH forced ventilation via 70 percent efficient air-to-air heat exchanger, and an internal heat load of 0.65 kilowatts. The indoor temperature is assumed to be 21° C in the daytime, set back to 18° C at night.
- In 1980 the average values for fuel consumption, floor area, and heating degree days were 98.5 gigajoules, 120 square meters, and 4,474 degree days, respectively, for oil heated single family dwellings. For conversion of fuel use to net heating requirements, a furnace efficiency of 66 percent is assumed (L. Schipper, "Residential Energy Use and Conservation in Sweden," *Energy and Buildings*, vol. 6, no. 1(1984): 15-38.).
- For a single story house with 130 square meters floor area, no basement, electric resistance heat, an indoor temperature of 21° C, and 4,010 degree-days.
- The average for 39 identical 4 bedroom, semi-detached houses (112 square meters of floor area, 3,300 degree-days).
- The Wolgast house has 130 square meters of heated floor space, 27 centimeters (45 cm) of mineral wool insulation in the walls (ceiling), quadruple glazing, low natural ventilation plus forced ventilation via air preheated in ground channels. Heat from the exhaust air is recovered via a heat exchanger. For 3,800 degree-days.
- The Faluhus has a floor area of 112 square meters. The more energy-efficient Version No. 2 (with extra insulation and heat recuperation) costs 3,970 SEK (US \$516) per square meter compared to 3,750 SEK (U.S. \$488) per square meter for Version No. 1. The annual electricity savings for the more efficient house would be 8960 kWh per year. The cost of saved energy (assuming a 6 percent discount rate and a 30-year life for the extra investment) would be 0.20 SEK per kilowatt hour (U.S. \$0.026 per kilowatt hour). For comparison electricity rates for residential consumers in Sweden consist of a fixed cost independent of consumption level of about 1,200 SEK (U.S. \$156) per year plus a variable cost of 0.25 SEK (U.S. \$0.032) per kilowatt hour.

Table 2. Breakeven Natural Gas Price (in 1987\$/GJ) for ISTIG Replacement of Existing Natural Gas-Fired Steam-Electric Plants

	<u>Breakeven Lifecycle Cost^a</u>	<u>Breakeven Cost in the First Year^b</u>
CF		
25%	5.41	6.86
35%	3.88	4.90
42%	3.23	4.09
45%	3.01	3.81
55%	2.46	3.12
65%	2.09	2.64
75%	1.81	2.28
85%	1.59	2.01

^a Neglecting differences between the O&M costs of ISTIG and steam-electric plants, the breakeven lifecycle price is given by:

$$CCR * CC_{istig} / (CF * 8760) = 0.0036 * (1/n - 1/0.47) * P,$$

where:

CC_{istig} = unit capital cost of ISTIG unit = \$400 per kW [Source: M.W. Horner (Marine and Industrial Engine and Service Division, Cincinnati, Ohio, of the General Electric Company), "Position Statement--Intercooled Steam-Injected Gas Turbine," testimony presented at the Committee Hearing for the 1988 Electricity Report of the California Energy Commission, held at the Southern California Edison Company, November 21-22, 1988]

CF = capacity factor of power plant,

n = efficiency of existing steam-electric plants = 0.318 (US average),

P = breakeven natural gas price (\$/GJ),

CCR = levelized annual capital charge rate = 0.1087 (for 30-year life, 6.1% real discount rate, 38% federal and state income tax rate, straight line depreciation, tax depreciation = book depreciation, 2% of capital per year for property taxes plus insurance--from 1986 EPRI Technical Assessment Guide).

^b The equation determining the breakeven price in the first year is the same as for the breakeven lifecycle gas price, except that CCR = 0.1376 instead of 0.1087 (see 1986 EPRI Technical Assessment Guide).

Table 3. Capital for Electricity^a

	1980	2000L ^b	2000H ^b
<u>Cost for New Generating Capacity (Jan 1986 \$/kW)</u>			
Hydroelectric	2630	3220	3940
Nuclear	1970	2430	2950
Fossil Fuel, Thermal	990	1180	1450
<u>Average Capital Requirements by Region (Jan 1986 \$/kW)</u>			
Industrial Countries			
Generation	1420	1920	2290
T & D	2630	2660	2900
Developing Countries			
Generation	1620	1980	2380
T & D	780	1630	2380
Centrally Planned Economies			
Generation	1310	1740	2220
T & D	1310	1880	2510
<u>Overall Capital Requirements for Electricity [10⁹ \$/year (% of GDP)]</u>			
Industrial countries	217 (2.2)	290 (2.0)	468 (2.7)
Developing countries	42 (1.5)	142 (2.6)	365 (5.5)
Centrally planned economies	58	141	223

Average Growth Rates (%/year)

	1980 - 2000L ^b	1980 - 2000H ^c
For GDP		
Industrial countries	2.0	3.0
Developing countries	3.5	4.5
For Primary Energy Consumption		
Industrial countries	0.15	1.3
Developing countries	2.5	4.7
Centrally planned economies	1.8	2.3
For Electricity Generation		
Industrial countries	1.3	2.5
Developing countries	4.5	6.8
Centrally planned economies	2.7	3.2

^a Source: H. K. Schneider and W. Schulz, Investment Requirements of the World Energy Industries 1980 - 2000, report prepared for the World Energy Conference (WEC) Study Group on Long-Term Investment Requirements, Needs, Constraints, and Proposals, World Energy Conference, London, September 1987.

^b 2000L (2000H) is for the WEC low (high) growth scenario.

Table 4. Natural Gas and Oil Resources and Production

	Natural Gas		Crude Oil	
	Resources ^a (EJ)	Production ^b (EJ/year)	Resources ^a (EJ)	Production ^b (EJ/year)
<u>Industrialized Countries</u>				
U.S. / Canada	1079.0 ^c	21.0	720.2	23.3
Western Europe	481.6	7.3	318.8	8.6
Australia / New Zealand	149.3	0.6	36.7	1.3
U.S.S.R. / Eastern Europe	2757.6	27.1	991.9	25.9
SUBTOTALS	4467.5	56.0	2067.6	59.1
<u>Developing Countries</u>				
Central America	228.3	1.3	342.7	6.5
South America	290.4	1.7	523.8	7.7
Asia	779.5	3.9	641.3	11.6
Africa	620.9	2.0	627.2	11.1
Middle East	2316.8	2.6	3175.1	23.0
SUBTOTALS	4235.9	11.5	5310.1	59.9
GLOBAL TOTALS	8703.4	67.5	7377.7	119.0

^a Proved reserves plus estimated reserve appreciation in discovered fields plus estimated recoverable undiscovered resources, as of January 1, 1985. (Source: C.D. Masters, E.D. Attanasi, W.D. Dietzman, R.F. Meyer, R.W. Mitchell, D.H. Root, "World Resources of Crude Oil, Natural Gas, Natural Bitumen, and Shale Oil," paper prepared for the 12th World Petroleum Congress, Houston, Texas, 1987)

^b Production in 1985 (Source: Energy Information Administration, 1987. International Energy Annual 1986, DOE/EIA-0219(86), US GPO, Washington, DC, 1987).

^c The resource estimate given here for the U.S. (650 EJ) may underestimate remaining gas resources. A more recent assessment carried out for the U.S. Department of Energy under the auspices of the Argonne National Laboratory (Argonne National Laboratory, "An Assessment of the Natural Gas Resource Base of the United States," Office of Policy, Planning, and Analysis, U.S. Department of Energy, Washington, DC, May 1988) estimated that remaining gas resources in the lower 48 states of the U.S. recoverable at wellhead prices less than \$2.75/GJ amount to 633 EJ, with 189 EJ of additional resources recoverable at costs in the range \$2.75/GJ to \$4.60/GJ.

Table 5. Installed Capital Cost for CIG/ISTIG System^a

		Jan 1986\$/kW
I. Process Capital Cost		
Fuel handling	36.7	
Blast air system	9.6	
Gasification plant	83.1	
Raw gas physical cleanup	7.7	
Raw gas chemical cleanup	150.9	
Gas turbine/HRSG	256.4	
Balance of plant		
Mechanical	33.0	
Electrical	48.4	
Civil	60.7	
SUBTOTAL		686.5
II. Total Plant Cost		
Process plant cost	686.5	
Engineering home office (10%)	68.6	
Process contingency (6.2%)	42.5	
Project contingency (17.4%)	119.6	
SUBTOTAL		917.2
III. Total Plant Investment		
Total plant cost	917.2	
AFDC (1.8%, 2-yr construction)	16.5	
SUBTOTAL		933.7
IV. Total Capital Requirement		
Total plant investment	933.7	
Preproduction costs (2.8%)	26.2	
Inventory capital (2.8%)	26.5	
Initial chemicals and catalysts	2.3	
Land ^b	1.3	
TOTAL		990

^a This is the estimated unit capital cost for a 42.1% efficient 110 MW Coal-fueled Integrated Gasification/Intercooled Steam-Injected Gas Turbine (CIG/ISTIG) system, which involves coupling a fixed-bed, airblown, Lurgi gasifier with chemical hot-gas clean-up to an ISTIG unit. From J.C. Corman, "System Analysis of Simplified IGCC Plants," report prepared for the U.S. Dept. of Energy at the Corporate Research and Development Center, General Electric Company, Schenectady, NY, ET-14928-13, September 1986. This cost estimate was obtained using the cost estimation procedures recommended by the Electric Power Research Institute (EPRI) in its 1986 Technical Assessment Guide, to facilitate comparisons with costs for alternative technologies.

^b For comparison a conventional new 34.6% efficient 500 MW coal-fired steam-electric plant is estimated to cost \$1360 per kW, and a 37.9% efficient 600 MW gas turbine/steam turbine combined cycle fired with gas derived from a Texaco gasifier (the technology demonstrated at Cool Water) is estimated to cost \$1500 per kW (Electric Power Research Institute, Technical Assessment Guide, Palo Alto, 1986).

Table 6. Installed Capital Cost for BIG/ISTIG System^a

		Jan 1986\$/kW	
I.	Process Capital Cost		
	Fuel handling	36.7	
	Blast air system	9.6	
	Gasification plant	83.1	
	Raw gas physical cleanup	7.7	
	Raw gas chemical cleanup	0.0	
	Gas turbine/MRSG	256.4	
	Balance of plant		
	Mechanical	33.0	
	Electrical	48.4	
	Civil	60.7	
	SUBTOTAL		535.6
II.	Total Plant Cost		
	Process plant cost	535.6	
	Engineering home office (10%)	53.6	
	Process contingency (6.2%)	33.2	
	Project contingency (17.4%)	93.2	
	SUBTOTAL		715.6
III.	Total Plant Investment		
	Total plant cost	715.6	
	AFDC (1.8%, 2-yr construction)	12.9	
	SUBTOTAL		728.5
IV.	Total Capital Requirement		
	Total plant investment	728.5	
	Preproduction costs (2.8%)	20.4	
	Inventory capital (2.8%)	20.4	
	Initial chemicals and catalysts	0.0	
	Land	1.3	
	TOTAL		770

^a This is the estimated unit capital cost for a 110 MW Biomass-fueled Integrated Gasification/Intercooled Steam-Injected Gas Turbine (BIG/ISTIG) system, which involves coupling a fixed-bed, airblown, Lurgi gasifier without chemical hot-gas clean-up to an ISTIG unit. The cost equals that for CIG/ISTIG (see Table 5) less the costs required for the chemical hot gas removal system (not needed because biomass contains negligible quantities of sulfur).

For many biomass applications 110 MW may be too large an installed capacity. Assuming the same scaling law for the capital cost of BIG/ISTIG as for CIG/ISTIG, the unit capital cost at other capacities is $2167 \text{ (MW)}^{-0.22}$, so that at 40 MW, for example, the capital cost would be \$960 per kW.

Table 7. Busbar Cost for Electricity from BIG/ISTIG Cogeneration Units Fired With Residues from the Production and Processing of Sugar Cane

	Jan. 1986 cents/kWh
Capital ^a	1.11
O&M ^b	0.46
Insurance ^c	0.05
Fuel preparation ^d	1.17
Fuel rent ^e	0.913 x P
Sale of steam ^f	- 0.0535 x P
Total	2.79 + 0.86 x P

^a For a 110 MW unit costing \$770/kW (Table 6), a 30-year life-time, a 10% discount rate, ($\rightarrow$ CRF = 0.1061), and a capacity factor of 84%.

^b The operating labor requirements for 6 operators (vs. 10 with hot gas chemical cleanup), @ \$20.10/hour = $\$1.057 \times 10^6$ /year = 0.13 cents/kWh. The maintenance costs: \$2,087,000 - \$527,000 (for raw gas chemical cleanup) = \$1,560,000 = \$13.7 per kW per year (1.8% of total capital requirement per year) = 0.19 cents per kWh (40% is labor). Administrative costs (30% of O&M labor) = $0.3 \times (0.13 + 0.4 \times 0.19) = 0.06$ cents/kWh. The variable O&M costs (raw water, solids disposal) are estimated to be 0.08 cents per kWh (see Table 14). Thus:

$$\text{Total O\&M} = 0.13 + 0.19 + 0.06 + 0.08 = 0.46 \text{ cents/kWh.}$$

^c The insurance cost is assumed to be 0.5% of the capital cost per year.

^d Inseason the hourly fuel requirements are 818 GJ of bagasse and 152 GJ of barbojo. The cost of briquetted bagasse (barbojo) = \$1.16 (\$1.35) per GJ. The average cost of fuel inseason is:

$$[(818 \text{ GJ/hr}) \times 1.16 + (152) \times 1.35]/(818 + 152) = \$1.19/\text{GJ.}$$

Charging all fuel to power generation, the average cost of fuel per kWh:

$$= 100 \times [(0.0036 \text{ GJ/kWh})/0.36] \times (\$1.19/\text{GJ}) = 1.19 \text{ cents/kWh (inseason);}$$

$$= 100 \times [(0.0036 \text{ GJ/kWh})/0.421] \times (\$1.35/\text{GJ}) = 1.15 \text{ cents/kWh (offseason).}$$

$$\text{The annual average cost of fuel per kWh} = (337.4 \times 1.19 + 508 \times 1.15)/845.4 = 1.17 \text{ cents/kWh.}$$

^e The annual average heat rate = $(3.6/0.36 \times 337.4 + 3.6/0.421 \times 508)/845.4 = 9.129 \text{ MJ/kWh}$ (39.4% efficient). Here P is the price (in \$/GJ) the distillery charges the utility for bagasse and barbojo.

^f Fuel for steam sold to the distillery amounts to 0.0062 GJ/liter of alcohol. But 11.58 kWh are produced per liter of alcohol. Thus steam fuel requirements per kWh of electricity produced is 0.000535 GJ/kWh.

Table 8. The Cost of Producing Ethanol from Sugar Cane^a

Jan. 1986 cents per liter	
Capital ^b	6.00
Fixed operating costs	
Labor	1.38
Maintenance	0.89
Supplies	0.09
Variable Operating Costs	
Sugar cane ^c	10.55
Other ^d	0.24
Steam	0.62 x P
Electricity ^e	0.38 x P _e - 0.38 x (2.79 + 0.860 P)
Credit for sale of bagasse, barbojo ^f	-10.57 x P
TOTAL	20.21 - 9.62 x P

- ^a For an autonomous distillery producing 120,000 liters of fuel alcohol per day, based on J. Goldenberg, J.R. Moreira, P.U.M. Dos Santos, and G.E. Sera, "Ethanol Fuel: a Use of Biomass Energy in Brazil," *Ambio*, vol. 14, nos. 4-5, pp. 293-297, 1985. Here it is assumed that the distillery is an all-electric unit that purchases all the electricity and steam it needs from the neighboring power plant (Table 7), which produces electricity from the bagasse and barbojo it purchases from the utility. Here the assumed capital cost for the distillery is \$7.6 million (this may be an overestimate because it is the cost for a distillery that provides for its own steam, mechanical power, and electricity requirements).
- ^b For a distillery lasting 15 years and operating 160 days per year at 90% availability. Also the cost of capital is assumed to be 10%, and the insurance cost is assumed to be 0.5% of the capital cost per year. Thus the assumed annual capital charge rate (including insurance) is 0.1365.
- ^c The estimated cost for sugar cane delivered to the distillery in Sao Paulo, Brazil, is \$7.7/tonne. Also, it is assumed that 73 liters of alcohol are produced per tonne of cane.
- ^d Steam requirements are assumed to be 1.5 kg or 4.22 MJ per liter of alcohol. If the alcohol distillery would have produced its own steam from bagasse it would have done so at 68% efficiency, so that 0.00621 GJ of fuel would be needed per liter. Here the price the distillery pays for this steam is just the price P (in \$/GJ) the distillery charges for the fuel it sells to the utility that it would otherwise have to consume to produce the same amount of steam (0.0062 GJ per liter of alcohol).

Table 8, cont.

- ^e The electricity requirements (kWh per tonne of cane) for an all-electric distillery are assumed to be the following:

Electric mills	9.0
Mechanical vapor recompression	5.7
Pumps, fans, conveyors, etc.	<u>13.0</u>
TOTAL	<u>27.7</u>

or 0.38 kWh per liter, since 73 liters of alcohol are produced per tonne of cane. Here P_e is the electricity price in cents per kWh.

- ^f Here it is assumed that the distillery sells all the bagasse and 78% of the barbojo (2219 GJ per hour or 0.1057 GJ per liter of alcohol) to the utility for a price P (\$/GJ).

Table 9. Cost of Alcohol and Electricity as a Function of the Rent Charged by the Distiller for Bagasse and Barbojo Sold to the Utility.

<u>Fuel Rent</u> (\$/GJ)	<u>Cost of Alcohol</u> (cents/liter)	<u>Cost of Electricity</u> (cents/kWh)	<u>Breakeven Capital Cost</u> <u>for Hydroelectricity</u> ^c (\$ per kW)
0.00	20.21	2.79	980
0.25	17.81	3.01	1057
0.50	15.40	3.22	1131
0.75	13.00	3.44	1208
1.00	10.59	3.65	1282
1.25	8.19	3.87	1359
1.50	5.78	4.08	1433
1.75	3.37	4.30	1510
2.00	0.97	4.51	1584
2.10	0.00	4.60	1615

^a From Table 7 the cost of electricity from a BIG/ISTIG unit is

$$P_e = 2.79 + 0.860 P \text{ cents per kWh,}$$

where P is rent on the fuel (in \$/GJ).

^b From Table 8 the cost of alcohol is

$$P_a = 20.21 - 9.62 \times P \text{ (cents per liter)}$$

^c Assuming a 10% discount rate, a 50-year lifetime for the hydroelectric facility, a 50% capacity factor, insurance costs of 0.5% of the installed capital cost per year, O&M costs of 1% of the installed capital cost per year, and 7% transmission losses for the hydro system (corresponding to the situation in Brazil, where 7% losses would be incurred in bringing hydropower in the Amazon region to the demand centers of Sao Paulo state, where local alcohol distilleries would be able to provide electricity as an alternative to building new hydroelectric facilities in the Amazon).

Table 10. Alternative Electricity Production Rates (kWh per capita per year)

Actual average for WE/JANZ region in 1975^a 4030Electricity required for "1 kW" scenario^b 2090

Electricity production in developing countries

	Actual Average from All Sources in 1980 ^c	Potential with Biomass at 2/3 Present Level of Bioenergy Use ^d
Nepal	16.0	1050
Ethiopia	16.4	910
Somalia	23.7	1180
Niger	37.6	610
Sudan	51.2	1550
Tanzania	55.2	1990
India	162	470
Bolivia	280	640
China	302	790
Thailand	314	1270
AVERAGE, ALL COUNTRIES	400	1030

^a The WE/JANZ region consists of Western Europe, Japan, Australia, New Zealand, S. Africa, and Israel. (Source: V.G. Chant, Two Global Scenarios: the Evolution of Energy Use and the Economy to 2030, RR-81-35, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1981)

^b The "1 kW" scenario is for a hypothetical developing country have the energy-using activity levels of the WE/JANZ region in 1975 but supplied with energy using energy end-use technologies that are either the best available on the market at present or, in a few instances, advanced technologies that could be commercialized over the next decade. (For a detailed description of the "1 kW" scenario see J. Goldenberg, T.B. Johansson, A.K.N. Reddy, R.H. Williams, Energy for a Sustainable World, World Resources Institute, Washington, DC, 1987.)

^c Source: World Bank, The Energy Transition in Developing Countries, Washington, DC, 1983.

^d Here it is assumed that 2/3 of the biomass presently consumed for energy (D.O. Hall, C.W. Barnard, P.A. Moss, Biomass for Energy in Developing Countries, Pergamon, Oxford, 1983) is used for electricity production using BIG/ISTIG technology, converting 42% of the energy contained in the raw biomass into electric energy (see Table 14).

Table 11. U.S. Fossil Fuel Use and Carbon Dioxide Emissions for 1987

	Electric Utilities			Entire U.S. Economy	
	Electricity Produced ^a (TWh)	Fuel Input ^a (EJ)	CO ₂ Emissions ^b (Teragrams)	Fuel Use ^a (EJ)	CO ₂ Emissions ^b (Teragrams)
Coal	1,464	16.03	393.4	18.96	465.4
Oil	118	1.33	26.5	34.42	685.2
N. Gas	273	3.10	41.7	18.12	244.0
Totals	1,855	20.46	461.6	71.50	1394.6

^a Energy Information Administration, "Monthly Energy Review, December 1987," Washington, DC, March 25, 1988.

^b The carbon emissions rates (as carbon dioxide) are assumed to be, on average, 13.5 Tg per EJ for natural gas, 19.9 Tg per EJ for oil, and 24.5 Tg per EJ for coal.

Table 12. Estimated Unused Wood Potentially Available for Energy in the US

Source	Mass of Dry Wood ^a (million tonnes/yr)	Energy Content of Wood ^b (Exajoules/yr)
Commercial Forest Land		
Excess Growing Stock	195	3.90
Mortality	86	1.73
Harvested Forest Sites		
Logging Residues	145	2.91
Standing Live & Dead Trees	18	0.36
Forest Products Industrial Waste	18	0.36
Waste Wood from Land Clearing	18	0.36
Urban Tree Removals & Wood Waste	<u>64</u>	<u>1.27</u>
TOTALS	544	10.9

^a Source: J.I. Zerba, "Forest Service Response to the National Energy Situation," pp. 33-58, in U.S. Dept. of Agriculture, Sixth Annual Solar, Biomass, and Wind Energy Workshop, Atlanta, Georgia, February 25-27, 1986.

^b Assuming a heating value of 20 GJ/tonne.

Table 13. Breakeven Biomass Price for BIG/ISTIG vs. Coal Competition

	Coal Price in 2000 ^a (\$/GJ)	Breakeven Biomass Price for Competition with		Electricity Produced w/Coal in 1985 ^b	
		Coal/Steam (\$/GJ)	CIG/ISTIG (\$/GJ)	(TWh)	(% of U.S. Total)
New England (NH, VT, MA, CT)	2.19	4.31	2.87	16.2	1.2
Middle Atlantic (NY, NJ, PA)	1.75	3.78	2.43	127.4	9.1
East North Central (OH, IN, IL, MI, WI)	1.90	3.96	2.58	335.6	23.9
West North Central (MN, IA, MO, ND, SD, NE, KS)	1.47	3.44	2.15	139.5	9.9
South Atlantic (DE, MD, VA, WV, NC, SC, GA, FL)	1.97	4.05	2.65	302.2	12.6
East South Central (KY, TN, AL, MS)	1.85	3.90	2.53	171.5	12.2
West South Central (AK, LA, OK, TX)	1.71	3.73	2.39	152.7	10.9
Mountain (MT, WY, CO, NM, AZ, UT, NV)	1.26	3.18	1.94	148.3	10.6
Northwest (WA, OR, AK)	1.65	3.66	2.33	8.8	0.6
U.S. average	1.76	3.79	2.44	1402	100.0

^a The average utility coal price in 1985 (Edison Electric Institute, Statistical Yearbook of the Electric Utility Industry/1985, 1986) plus \$0.10/GJ, the increment in the U.S. average coal price projected for the period 1985-2000 by the U.S. Dept. of Energy [Energy Information Administration, Annual Energy Outlook 1987, with Projections to 2000, DOE/EIA-038(87), March 1988].

^b To determine the maximum biomass price at which BIG/ISTIG electricity would be competitive with electricity from a conventional coal-fired steam-electric (CIG/ISTIG) power plant, the BIG/ISTIG busbar cost (Table 14) is set equal to that for a coal-fired steam-electric plant (Table 15) [CIG/ISTIG plant (Table 16)]. Thus the breakeven biomass price is given by:

$P_b = 1.65 + 1.216 \times P_c$ dollars per GJ, for steam-electric coal plants,

$P_b = 0.68 + P_c$ dollars per GJ, for CIG/ISTIG plants (neglecting the potential sulfuric acid byproduct credit),

where P_c is given in \$/GJ.

^c Edison Electric Institute, Statistical Yearbook of the Electric Utility Industry/1985, 1986.

Table 14. Busbar Cost for Electricity from BIG/ISTIG Power Units Fueled With Fuelwood from Bioenergy Plantations

	Jan. 1986 cents/kWh
Capital ^a	1.27
O&M ^b	0.52
Fuel price ^c	$0.855 \times P_b$
Total	$1.79 + 0.855 \times P_b$

^a Assuming an installed capital cost of \$770/kW (see Table 6) for a 110 MW unit, a 30-year lifetime, a 6.1% real discount rate, a corporate income tax rate of 38%, and property taxes and insurance equal to 2% of the installed capital cost per year, so that the annual capital charge rate is 0.1087 (from the EPRI Technical Assessment Guide, 1986). Also the capacity factor is assumed to average 75%.

^b The O&M costs for biomass are assumed to be those for coal systems (J.C. Corman, "System Analysis of Simplified IGCC Plants," report prepared for the U.S. Dept. of Energy at the Corporate Research and Development Center, General Electric Company, Schenectady, NY, ET-14928-13, September 1986) less the costs O&M costs associated with the chemical hot gas cleanup system needed for coal systems but not biomass systems.

Thus, the operating labor requirements for 6 operators (compared to 10 with hot gas chemical cleanup), @ \$20.10 per hour = $\$1.057 \times 10^6$ per year = 0.15 cents/kWh

The maintenance costs: \$2,087,000 - \$527,000 (for raw gas chemical cleanup) = \$1,560,000 = \$14.2 per kW per year (1.8% of total capital requirement per year) = 0.22 cents per kWh (40% is labor)

Administrative costs (30% of O&M labor) = $0.3 \times (0.15 + 0.4 \times 0.22) = 0.07$ cents per kWh

The variable O&M costs (raw water, solids disposal) are estimated to be \$550,500, or 0.08 cents per kWh.

Total O&M = $0.15 + 0.22 + 0.07 + 0.08 = 0.52$ cents per kWh

^c The efficiency of power generation is assumed to be 42.1%, wood to busbar, the same as for firing with coal (J.C. Corman, "System Analysis of Simplified IGCC Plants," report prepared for the U.S. Dept. of Energy at the Corporate Research and Development Center, General Electric Company, Schenectady, NY, ET-14928-13, September 1986). Here P_b is the price of biomass fuel (in \$/GJ).

Table 15. The Cost of Electricity from New Coal Steam-Electric Power Plants^a

Type	
Unit Size [MW(e)]	500
Efficiency (Coal-to-Busbar)	34.6
Unit Capital Cost (Jan 1986\$/kW)	1360
<u>Levelized Busbar Cost</u> (Jan 1986 cents per kWh)	
Capital ^b	2.25
O&M	0.95
Fuel ^c	$1.04 \times P_c$
TOTAL	$3.20 + 1.04 \times P_c$

^a For a conventional coal-fired subcritical steam plant with wet limestone flue gas desulfurization, for bituminous coal, U.S. Midwest conditions. Unit capital costs, efficiencies, O&M costs, and other plant characteristics are from the 1986 Electric Power Research Institute's 1986 Technical Assessment Guide.

^b Assuming a 30-year lifetime, a 6.1% real discount rate, a corporate income tax rate of 38%, and property taxes and insurance equal to 2% of the installed capital cost per year (so that the annual capital charge rate is 0.1087 (from the 1986 EPRI Technical Assessment Guide). Also the capacity factor is assumed to average 75%.

^c Here P_c is the price of coal (in \$/GJ). Note that the U.S. DOE has projected that the average utility price of coal in the U.S. in the year 2000 will be \$1.76/GJ [Energy Information Administration, "Annual Energy Outlook 1987, with Projections to 2000," DOE/EIA-0383(87), March 28, 1988].

Table 16. Busbar Cost for Electricity from CIG/ISTIG Power Units Fueled With Coal

	Jan. 1986 cents/kWh
Capital ^a	1.64
O&M ^b	0.53 (0.73)
Fuel ^c	$0.855 \times P_c$
Total ^b	$2.17 + 0.855 \times P_c$ ($2.37 + 0.855 \times P_c$)

- ^a Assuming an installed capital cost of \$990/kW (see Table 5) for a 110 MW unit, a 30-year lifetime, a 6.1% real discount rate, a corporate income tax rate of 38%, and property taxes and insurance equal to 2% of the installed capital cost per year (so that the annual capital charge rate is 0.1087 (from the EPRI Technical Assessment Guide, 1986). Also the capacity factor is assumed to average 75%.
- ^b From J.C. Corman, "System Analysis of Simplified IGCC Plants," report prepared for the U.S. Dept. of Energy at the Corporate Research and Development Center, General Electric Company, Schenectady, NY, ET-14928-13, September 1986. The first value given for the O&M cost includes a credit for the sale of the sulfuric acid byproduct of hot gas cleanup. The second value (given in parentheses) neglects this credit. This credit could be realized initially, but with wide use of this technology the sulfuric acid market would become saturated.
- ^c The efficiency of power generation is 42.1% (see J.C. Corman, "System Analysis of Simplified IGCC Plants," report prepared for the U.S. Dept. of Energy at the Corporate Research and Development Center, General Electric Company, Schenectady, NY, ET-14928-13, September 1986). Here P_c is the price of coal (in \$/GJ).

Table 17. Present and Projected SRIC Productivities and Delivered Fuel Costs for Selected Regions and Species^a

Region (Species)	Productivity (ODT/ha/year) ^c			Delivered Cost (Jan 1986\$/GJ) ^d		
	Present	Targets for 2000 Conser- vative	Opti- mistic	Present	Targets for 2000 Conser- vative	Opti- mistic
Northeast (Hybrid Poplar)	9.2	14	16	4.63	3.2	2.7
Lake States (Hybrid Poplar)	8.0	12	15	4.94	3.4	2.7
Great Plains (Black Locust)	11.5	15	18	4.03	3.1	2.5
Southeast (Sycamore)	7.7	13	16	4.88	3.1	2.5
Pacific Northwest (Bl. Cottonwood)	16.0	27	30	3.79	2.5	2.2
So. Florida (Eucalyptus)	14.2	22	25	3.93	2.8	2.5

^a The estimates presented here are based on research carried out under the Department of Energy's Short Rotation Woody Crops Program and are from Robert D. Perlack and J. Warren Ranney, "Economics of Short-Rotation Intensive Culture for the Production of Wood Energy Feedstocks," *Energy*, vol. 12, no. 12, pp. 1217-1226, 1987, except that a cost of \$0.76 per GJ was added to the Perlack/Ranney costs of delivered fuelwood to take into account drying and 6 months storage (from Table 3-4, page 3-18, of P.R. Blankenhorn et al., "Net Financial and Energy Analyses for Producing Populus Hybrid Under Four Management Strategies First Rotation," ORNL/Sub/79-07928/1, June 1985)--items not included in the Perlack/Ranney cost estimates.

^b Present productivities, in oven dry tonnes (ODT) per hectare per year are current average estimates for genetically unimproved or wild planting stock grown on experimental plots.

^c The productivity gains projected by Perlack and Ranney are attributable to selection and breeding programs only and do not take into account productivity increases that could come from more speculative genetic engineering approaches to tree growth.

^d The costs include land rent, infrastructure, establishment, planting, weed control, fertilization, pest control, administration, harvesting, chipping, harvest road access, loading, conveying, transport 40 km to the processing facility, drying, 6 months storage, and a return on investment equal to 20% of the delivered cost exclusive of drying and storage.

Table 18. Potential SRIC-Based Electricity Production on Highly Erodable Cropland

Region	<u>Area of Highly Erodable Land</u> (million hectares)	<u>Electricity Production Potential With BIG/ISTIG^a</u> (TWh per Year)
Northeast	1.5	35.1
Appalachia	2.4	55.9
Southeast	1.0	23.4
Delta	0.9	21.8
Corn Belt	7.7	180.9
Lake States	1.6	36.9
Northern Plains	5.6	130.7
Southern Plains	5.6	130.7
Mountain	6.0	139.2
Pacific	1.4	32.2
Subtotal ^b	33.6	786.9
Additional ^c	14.2	331.4
TOTAL U.S. ^c	47.8	1118.3

^a Here it is assumed that (i) SRIC plantations are installed on all highly erodable farmland, with an average productivity of 10 tonnes per hectare per year, and (ii) this wood is used to generate electricity in 42% efficient BIG/ISTIG power plants (see Table 14).

^b Land under cultivation of an annually produced commodity with an erodability index of 8 or greater. This is the definition of highly erodable land according to the Highly Erodable Land (HEL) Subtitle of the 1985 Food Security Act. The soil conservation compliance provisions of this Subtitle requires soil conservation plans to be implemented on highly erodable cropland so defined as a provision for access to Government commodity program benefits.

Tolerable erosion rates have been established for each soil type. (This is the rate that can be allowed to continue indefinitely without damage to the soil. Typical tolerable erosion rate values are in the range 2 to 11 tonnes per hectare per year). The erodability index, which describes the relative susceptibility of a soil to erosion damage, is the following ratio: a measure of the physical attributes of a soil's erodability divided by the soil loss tolerance level. The greater the erodability index, the more susceptible the soil to erosion damage.

^c Altogether some 48 million hectares (118 million acres) are considered to be highly erodable cropland. However 14 million hectares (35 million acres) are considered to be in compliance with the HEL Subtitle or are not considered cropland according to this Subtitle.

Table 19. Estimated NOx Emissions for Alternative Cycles Based on the LM-5000^{a,b}

	Adiabatic Flame Temperature (T°K)		NOx Emission Rate (ppm @ 15% O ₂)	
	2530	260		
1. Uncontrolled Simple Cycles ^c				
2. Steam-Injected Cycles ^d	STIG	ISTIG	STIG	ISTIG
Dry ^e	2548	2471	301	159
S/F ^e = 1.0	2406	2329	89.5	43.6
S/F ^e = 2.0	2274	2199	25.3	11.6
S/F ^e = 3.0	2158	2085	7.4	3.2
3. Chemically Recuperated, Steam-Injected Cycles	CRSTIG	CRISTIG	CRSTIG	CRISTIG
Dry ^e	2223	2161	15	7.6
S/F ^e = 0.2	2107	2048	4.1	2.0
S/F ^e = 0.3	2055	1997	2.2	1.0
S/F ^e = 0.5	1959	1905	0.63	0.29

^a The adiabatic flame temperature (AFT) is calculated for stoichiometric conditions--for methane @ 300 °K in simple and dry STIG/ISTIG cycles; for methane @ 400 °K in wet STIG/ISTIG cycles; for a mixture (@ 950 °K) of 10% methane, 62% steam, 22% hydrogen, 1% carbon monoxide, and 5% carbon dioxide (a typical fuel composition expected from the steam-reforming of natural gas) for CRSTIG/CRISTIG cycles. (A reheat turbine would be needed to achieve the turbine exhaust temperature needed for steam reforming. Because of the reduced oxygen level in the reheat combustion "air", the AFT and hence NO_x formation in the reheat combustor would be significantly lower than in the primary combustor. This effect is neglected here.) The temperature of steam for NO_x control is assumed to be 578 °K. For the calculated AFT, the indicated NO_x emission level is obtained from an empirical relationship between AFT and NO_x emissions [4]. For the lowest AFTs considered, empirical data are not yet available, and the indicated NO_x emissions, obtained by extrapolation, may underestimate actual emissions. While thermal NO_x emissions are strongly correlated with AFT, prompt NO_x emissions are not. At high AFT, thermal emissions dominate; at low AFT, prompt NO_x emissions become more important.

^b For a compression ratio of 27.6:1, 31.3:1, and 33.5:1, and an air temperature at the compressor exit of 787 °K, 816 °K, and 658 °K, for the simple cycle, STIG/CRSTIG cycles, and ISTIG/CRISTIG cycles, respectively.

^c The uncontrolled NO_x emissions rate for this simple cycle turbine is higher than for the turbines used in combined cycles, because the low pressure ratio of the gas turbines used in combined cycles leads to a lower compressor exit temperature and hence a lower AFT.

^d "Dry" means that all steam is injected with the dilution air (i.e. no steam is injected into the primary combustion zone).

^e S/F is the molar ratio of steam/fuel for steam injected into the primary combustion zone for NO_x control.

Table 20. Breakeven Natural Gas Price (in 1987\$/GJ) for ISTIG Replacement of Existing Natural Gas-Fired Steam-Electric Plants as an Alternative to SCR Retrofits of Existing Steam-Electric Plants for NO_x Control in the South Coast Basin in California

	Breakeven Lifecycle Cost ^a	Breakeven Cost in the First Year ^b
CF		
25%	3.69	4.67
35%	2.63	3.33
45%	2.05	2.59
55%	1.67	2.12
65%	1.41	1.80
75%	1.23	1.56
85%	1.08	1.37

^a Neglecting differences between the O&M costs of ISTIG and steam-electric plants, the breakeven lifecycle price is given by:

$$CCR*(CC_{istig} - CC_{scr})/(CF*8760) = 0.0036*(1/n - 1/0.47)*P,$$

where:

CC_{istig} - unit capital cost of ISTIG unit - \$400 per kW [Source: M.W. Horner (Marine and Industrial Engine and Service Division, Cincinnati, Ohio, of the General Electric Company), "Position Statement--Intercooled Steam-Injected Gas Turbine," testimony presented at the Committee Hearing for the 1988 Electricity Report of the California Energy Commission, held at the Southern California Edison Company, November 21-22, 1988]

CC_{scr} - unit capital cost of SCR retrofit of existing plant - \$128/kW (Source: California Energy Commission Staff, Resource Case Analysis Report, testimony presented at the Committee Hearing for the 1988 Electricity Report of the California Energy Commission, held at the Southern California Edison Company, November 21-22, 1988)

CF - capacity factor of power plant,

n - efficiency of existing steam-electric plants - 0.318 (US average),

P - breakeven natural gas price (\$/GJ),

CCR - levelized annual capital charge rate - 0.1087 (for 30-year life, 6.1% real discount rate, 38% federal and state income tax rate, straight line depreciation, tax depreciation - book depreciation, 2% of capital per year for property taxes plus insurance--from 1986 EPRI Technical Assessment Guide).

^b The equation determining the breakeven price in the first year is the same as for the breakeven lifecycle gas price, except that CCR = 0.1376 instead of 0.1087 (see 1986 EPRI Technical Assessment Guide).

Table 21. Estimated Amorphous Silicon Solar Module Production Cost for a Factory Producing 10 MW_p per Year of 6 Percent Efficient Solar Modules (a).

	Dollars per W _p
Equipment Depreciation (b)	0.41
Direct Materials (c)	0.46
Direct Labor and Fringe Benefits (d)	0.16
Indirect Labor (e)	0.07
Indirect Expenses	0.06
Total	1.16

a For a factory planned by Solarex (Source: D.E. Carlson, "Low-Cost Power from Thin-Film Photovoltaics," in *Electricity*, T.B. Johansson, B. Bodlund, and R.H. Williams, eds., University of Lund Press, Lund, Sweden, 1989).

b For a five-year depreciation period and a capital cost for equipment (computer integrated manufacturing) in a 20,000 square foot facility estimated to be \$16,500,000.

c For 1 foot x 4 foot modules produced with an overall yield of 84%. The following is a breakdown of the materials cost:

Material	-----Cost-----	
	\$/W _p	\$/m ²
Glass (chemically strengthened)	0.23	13.8
Silane	0.07	4.2
Encapsulant	0.04	2.6
Frame	0.03	1.8
Diborane, phosphine	0.03	1.8
Stannic chloride	0.02	1.2
Wire, other process gases	0.02	1.2
Aluminum	0.02	1.2
Total	0.46	27.6

d 83 direct employees, 5 day work week, 2.5 shifts per day.

e 17 indirect employees.

Table 22. Production Cost of Amorphous Silicon Solar Cells (\$ per W_p)

Annual Production		5-Year Depreciation						10-Year Depreciation w/Reductions in Materials' Costs ^c		
Million sq. m.		0.167			1.67			1.67		
MWp		10	20	30	100	200	300	100	200	300
Efficiency		6% ^a	12% ^a	18% ^b	6% ^a	12% ^a	18% ^b	6%	12%	18%
Variable Costs										
Direct Labor		0.16	0.08	0.05	0.06	0.03	0.02	0.06	0.03	0.02
Materials		0.46	0.23	0.15	0.46	0.23	0.15	0.22	0.11	0.07
Fixed Costs										
Indirect Labor		0.07	0.035	0.023	0.01	0.005	0.003	0.01	0.005	0.003
Indirect Expenses		0.06	0.03	0.02	0.01	0.005	0.003	0.01	0.005	0.003
Depreciation		0.41	0.205	0.14	0.40	0.20	0.133	0.20	0.10	0.065
Total Cost		1.16	0.58	0.39	0.94	0.47	0.31	0.50	0.25	0.16

^a These estimates were made by Carlson [David E. Carlson (General Manager, Thin Film Division, Solarex, New Town, Pennsylvania), "Low-Cost Power from Thin-Film Photovoltaics," in *Electricity*, T.B. Johansson, B. Bodlund, and R.H. Williams, eds., University of Lund Press, Lund, Sweden, 1989], based on computer integrated manufacturing technology under development at Solarex, in Newtown, Pennsylvania. In this analysis detailed cost estimates were made for present-day production technology using 6% efficient cells, and these cost estimates were extrapolated to 12% efficient cells, assuming that the costs per unit area will not change as the efficiency is increased.

^b These cost estimates are obtained by extrapolating Carlson's estimates to 18% efficient cells, with the assumption that the cost per unit area will not change as the efficiency is increased.

^c Two possibilities for cost reduction are taken into account here: (i) reduced materials costs and (ii) an extended equipment depreciation period. Carlson estimates that the collective effect of the materials cost reduction efforts discussed in the text could be to reduce the cost of materials from \$0.46 per peak Watt for 6% efficient cells manufactured at a rate of 10 MW per year to perhaps \$0.11 per peak Watt for 12% efficient cells produced at a rate of 100 MW per year (D.E. Carlson, "Low-Cost Power from Thin-Film Photovoltaics"). Since the pace of innovation will probably slow as the technology matures, it is assumed here that the depreciation period is doubled from five to ten years.

Table 23. Solar PV Electrolytic Hydrogen System Parameters^a

PV ARRAY:	Amorphous silicon solar cells Tilted, fixed, flat-plate array PV module efficiency = 12-18% System efficiency (ex. module) = 0.85 PV module cost = \$0.2-0.4/Wp Balance of systems cost = \$33/m ² Annual operation and maintenance cost ^b = \$0.45/m ² 30-Year PV system lifetime Indirect costs add 25% to capital costs
PV ARRAY/ELECTROLYZER COUPLING:	Direct connection, 93% coupling efficiency ^c
ELECTROLYZER:	Atmospheric pressure, unipolar electrolyzer ^d Rated voltage = 1.74 Volts Rated current density = 134 mA/cm ² Operating current density = 268 mA/cm ² Efficiency at operating voltage = 84% Installed capital cost of system = \$170/kWDC in Annual O&M = 2% of capital cost 20-Year electrolyzer lifetime
ECONOMIC ASSUMPTIONS:	All costs expressed in 1986 US\$ Discount rate = 6.1% ^e Annual insurance cost = 0.5% of capital cost ^e All income/property taxes are neglected

^a For PV hydrogen system > 10 MW in size.^b Suggested by field data from large PV arrays. G.J. Shustar, J.H. Caldwell, R.F. Reinohl and J.H. Wilson, "ARCO Solar Field Data for Flat Plate PV Arrays," 18th IEEE PV Specialists' Conference, Las Vegas, October 1985.^c C. Carpetis, International Journal of Hydrogen Energy, v. 7, p. 287, 1982; C. Carpetis, IJHE, v. 9, p. 969, 1984; R.W. Leigh, P.D. Metz and K. Michalek, Brookhaven National Laboratory Report BNL-34081, December 1983; P.D. Metz and M. Piraino, BNL-51940, July 1985.^d Electrolyzer operating characteristics and costs are based on currently available unipolar technology. We have assumed that no rectifier is needed. R.L. Leroy and A.K. Stuart, "Advanced Unipolar Electrolysis," and M. Hammerli, "When Will Electrolytic Hydrogen Become Competitive?" IJHE, v. 9, pp.25-51, 1984.^e These values are used by the Electric Power Research Institute in evaluating utility scale power production facilities (EPRI, Technical Assessment Guide, Vol.1: Electricity Supply, EPRI P-4463-SR, 1986).

Table 24. Estimated Costs for Alternative Sources of Electrolytic Hydrogen

	PV ^a		NUCLEAR ^b		HYDROPOWER ^c		WIND ^d	
	nmod-12% \$0.4/Wp	nmod-18% \$0.2/Wp	Current	Target	(GLOBAL AVERAGES) 2000L 2000H	LOW	HIGH	
ELECTRICITY GENERATION								
System Size (MW)	10	10	1100	1100	-	-	(40 x 2.5)	
Capital Cost (\$/kW)	992	564	2970	1620	3260	4000	1340	1580
Plant Life (years)	30	30	30	30	50	50	30	30
Capacity Factor	0.271	0.271	0.566	0.65	0.47	0.47	0.35	0.35
O & M (mills/kWh)	1.9	1.2	12.0	6.5	2.9	2.9	8.7	10.3
Fuel (mills/kWh)	-	-	7.5	7.5	-	-	-	-
Electricity Production Cost (mills/kWh)	34.7	19.8	66.5	36.3	55.4	70.2	43.0	50.8
HYDROGEN PRODUCTION COST ^e (\$/GJ)								
Electricity	11.47	6.55	22.91	12.51	19.01	24.18	14.83	17.48
Electrolyzer	2.52	2.52	1.47	1.27	1.76	1.76	2.36	2.36
Total	14.0	9.1	24.4	13.8	20.8	25.9	17.2	19.8

^a For details see J.M. Ogden and R.H. Williams, "Solar Hydrogen and the Revolution in Amorphous Silicon Solar Cell Technology", FU/CEES Report No. 231, Center for Energy and Environmental Studies, Princeton University, Princeton, New Jersey, February 1989.

^c The indicated hydro capital costs and capacity factors are global average estimates for the year 2000 (H. K. Schneider and W. Schulz, Investment Requirements of the World Energy Industries 1980-2000, World Energy Conference, 1987). The hydro O&M costs are EPRI estimates for the indicated capacity factor (EPRI, 1986).

^d For mass-produced 2.5 MW wind turbines configured to produce 100 MW (J. I. Lerner, "A Status Report on Wind Farm Energy Commercialization in the United States, with Emphasis on California," paper presented at the 4th International Solar Forum, Berlin, FRG, October 6-9, 1982). The O&M cost is assumed to be 2% of the initial capital cost per year.

^e For non-FV electricity sources, unit electrolyzer capital costs are assumed to be 25% higher because of the rectifier, which is assumed to be 96% efficient.

Table 25. Cost of Hydrogen Transmitted 1600 km^a

	mod -	12%	18%
		\$0.40/Wp	\$0.20/Wp
Hydrogen production ^a		13.96	9.07
Compression to 6.9 MPa (1000 psia)		1.48	1.21
Hydrogen storage (in depleted natural gas wells)		0.20	0.19
Pipeline (1600 km)		<u>0.35</u>	<u>0.35</u>
Hydrogen cost at end of pipeline		15.99	10.82

^a The hydrogen production cost is from Table 24. All other costs are from J.M. Ogden and R.H. Williams, "Solar Hydrogen and the Revolution in Amorphous Silicon Solar Cell Technology", PU/CEES Report No. 231, Center for Energy and Environmental Studies, Princeton University, Princeton, New Jersey, February 1989.

Table 26. Estimated Production Costs for Synthetic Liquid and Gaseous Fuels

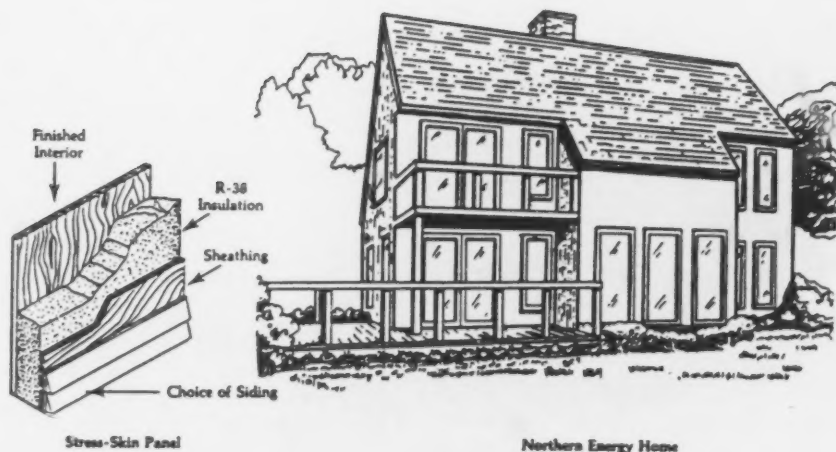
FUEL	SYNFUEL PLANT		Fuel Production Cost ^b (\$/GJ)
	Plant Size (1000 GJ/day)	Installed Cost (\$10 ⁶)	
Gasoline Derived from Coal	176	5107	16.2
Methanol Derived from Coal	322	3860	7.9
	32.2	567	10.0
Ethanol Derived from			
Sugar cane (Brazil)	2.68	7.7	8.0
Corn (US)	13	95.2	14.4
Synthetic Gas Derived from Coal (c)			
High heating value gas	264	1820	5.7
	88	756	6.4
	26.4	341	7.9
Intermediate heating value gas	264	1370	5.1
PV Hydrogen (Southwestern US)			
nmod=18%, \$0.2/Wp	0.183 ^d	8.0	9.1
nmod=12%, \$0.2/Wp		9.6	10.7
nmod=18%, \$0.4/Wp		10.9	12.3
nmod=12%, \$0.4/Wp		12.6	14.0

^a The cost estimates presented here were derived using a self-consistent set of assumptions to ensure that the cost comparisons for alternative technologies are meaningful (Source: J.M. Ogden and R.H. Williams, "Hydrogen and the Revolution in Amorphous Silicon Solar Cell Technology," PU/CEES Report No. 231, Center for Energy and Environmental Studies, Princeton University, Princeton, New Jersey, February 1989).

^b The production cost includes plant capital, feedstock and operation and maintenance costs, but not the costs of transmission or storage.

^c For Lurgi Dry Ash process with Western US coal.

^d This corresponds to a 10.8 MWp PV array coupled to an 84% efficient unipolar electrolyzer, where the coupling efficiency is 93%. The peak PV hydrogen output is 8.4 MW, and the average output is 183 GJ/day for a system located in the Southwestern US, with average insolation of 271 watts per square meter. There should be no significant economies of scale for PV powered electrolyzers above about 2-10 MW.



Highly insulating "stress-skin panels" are featured in some super-insulated houses ("Stress-Skin Panels," *Progressive Builder* [September 1986]: 23-26), such as the Northern Energy Home (NEH) offered in the northeastern United States. At the construction site, 4 feet x 8 feet (1.2 meters x 2.4 meters) stress-skin panels are mounted on a post-and-beam frame. The factory-assembled panels, containing thick (8-inch [20-centimeters]) rigid polystyrene insulation, are made to fit together easily for rapid construction. Doors and windows are foam-sealed into the panels at the factory. Because of the tight construction, natural air infiltration is low, so that forced ventilation is used with a heat exchanger that extracts heat from the stale exhaust air and warms the fresh incoming air.

The extra costs for insulation and forced ventilation are more than offset by various savings. Prefabrication of the panels leads to time and labor savings in construction. In addition, temperatures can be kept uniform throughout the house with a couple of small space heaters, which cost much less than a central furnace with ductwork. For a ranch-style NEH with a floor area of 1,300 square feet (120 square meters) in the New York City area, the annual fuel cost for natural gas would be less than \$50 per year—compared to more than \$400 per year for heating the average house in the Middle Atlantic region of the United States.

Figure 1.

Cross-Section of a "Stress-Skin Panel (Left) Used in a Northern Energy Home (Right)



Toyota AXV

Introduced in late 1985, the AXV has a fuel economy of 2.4 l/hk (98 mpg) on the combined urban/highway test administered by the U.S. Environmental Protection Agency. For comparison, the average U.S. automobile gets about 12.4 l/hk (19 mpg), and the average car in the rest of the world about 9.8 l/hk (24 mpg). High fuel economy is achieved with the systematic application of presently available technologies: low weight (650 kg [1,430 lb]) from extensive use of plastics and aluminum, low aerodynamic drag, a direct-injection diesel engine (the kind used in trucks), and a continuously variable transmission.

Source: Toyota press release, October 23, 1985.

Figure 2.

The Toyota AXV, a Prototype Four- to Five-Passenger, Super Fuel-Efficient Car

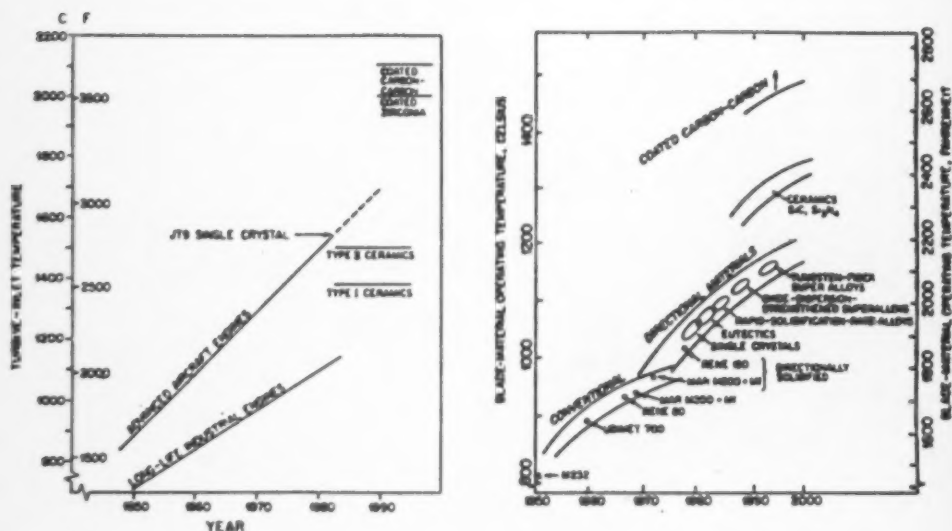


Figure 3.

The Trend in Turbine Inlet Temperature for Advanced Aircraft Jet Engines and Long-Life Industrial Turbines (Left) and Turbine Blade Material Operating Temperature (Right)

Note: When an aircraft engine is modified for stationary applications the rated turbine inlet temperature is reduced about 110°C (200°F) to promote long-life operation.

Source: D. G. Wilson, *The Design of High-Efficiency Turbomachinery and Gas Turbines*, MIT Press, Cambridge, Massachusetts, 1984.

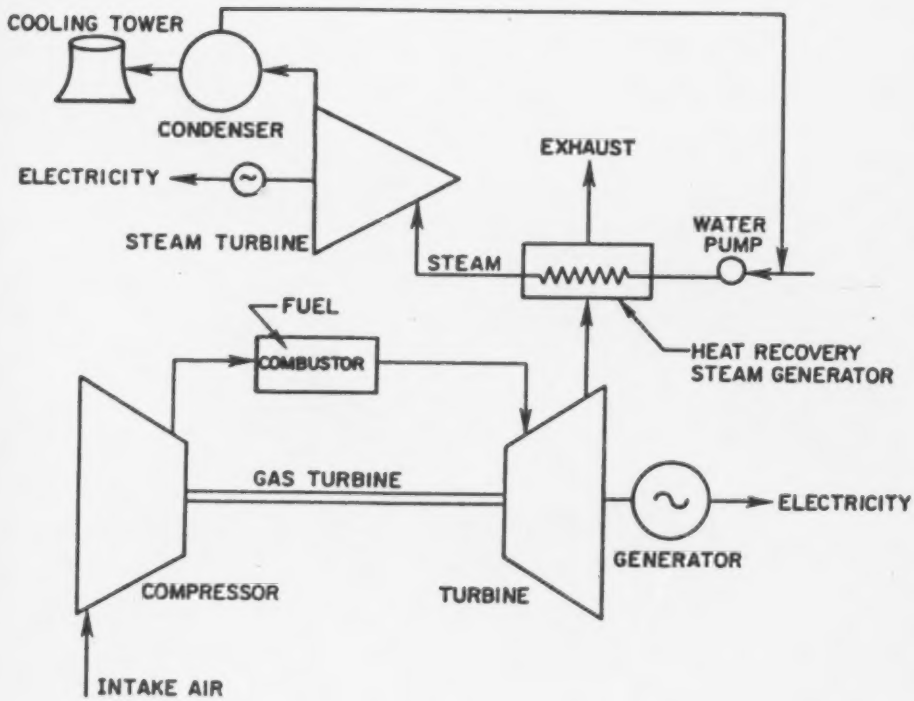


Figure 4.

Combined Cycle for Power

Like cogeneration cycle based on simple cycle gas turbine, except that steam from HRSG is used to produce extra power in condensing steam turbine.

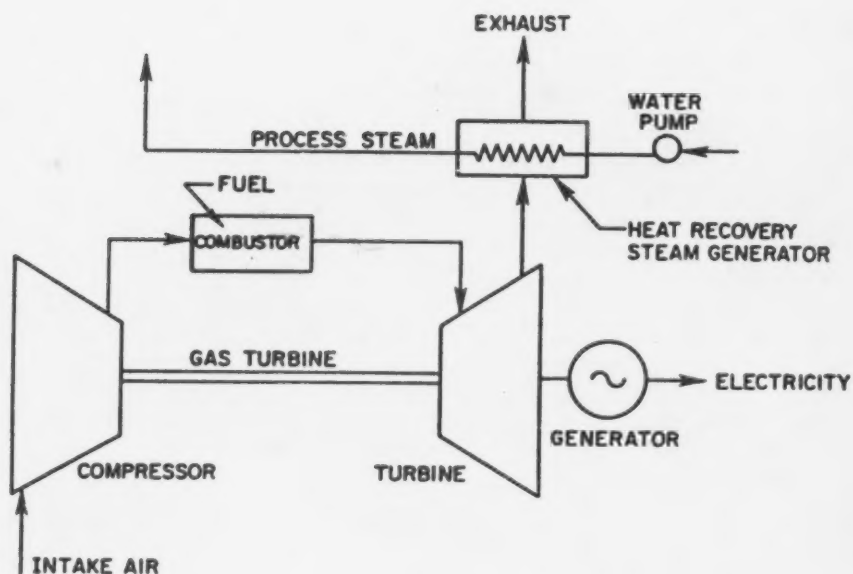


Figure 5.

Cogeneration Based on the Simple Cycle Gas Turbine

Fuel burns in air pressurized by compressor, combustion products drive turbine, and hot turbine exhaust gases are used to raise steam in HRSG for heating.

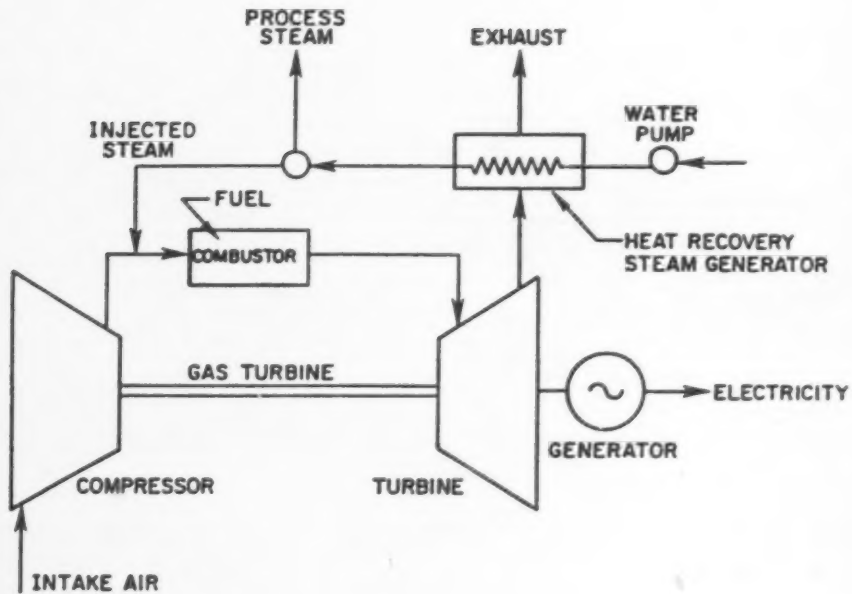


Figure 6.

Steam-Injected Gas Turbine (STIG)

Like cogeneration based on simple cycle gas turbine, except that steam not needed for heating is injected into combustor for increased power output and higher electrical efficiency.

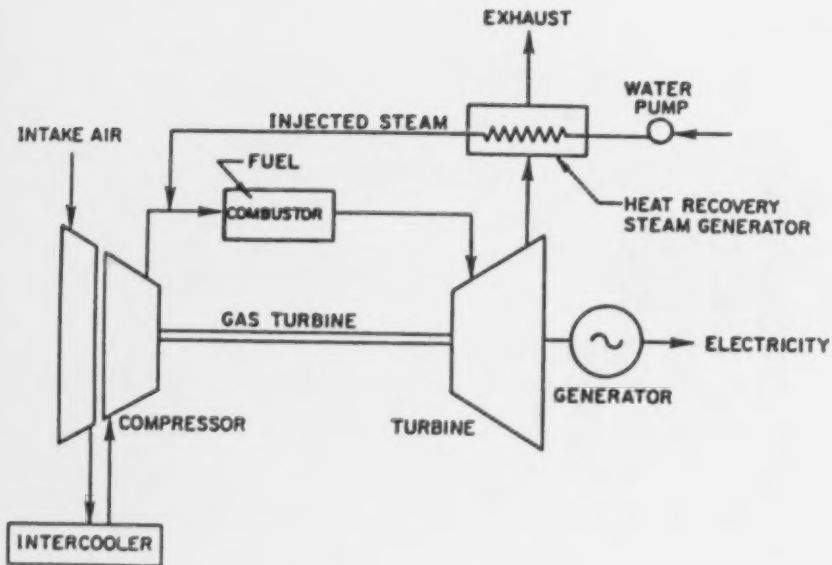


Figure 7.

Intercooled Steam-Injected Gas Turbine (ISTIG)

Like STIG with full steam injection except that intercooler between compressor stages allows for operation at much higher turbine inlet temperature because of improved air cooling of turbine blades.

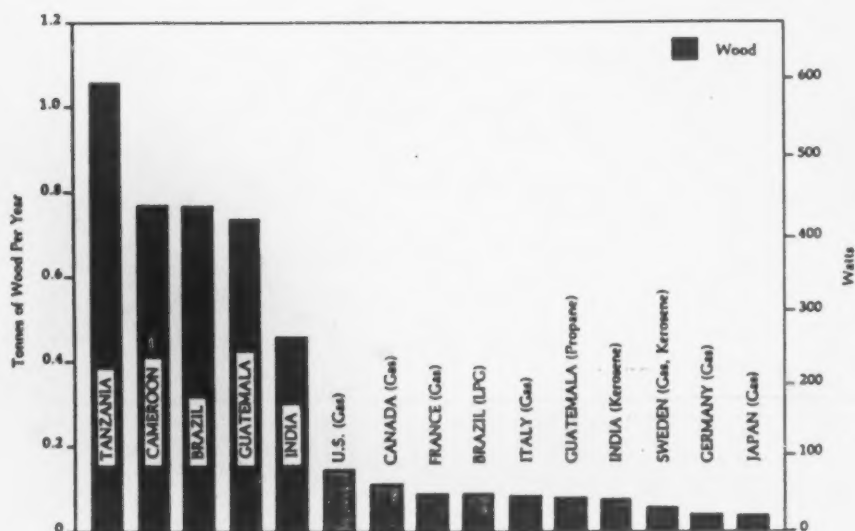


Figure 8.

Per capita energy use rates for cooking with fuelwood and high-quality energy carriers. For both wood stoves and stoves using high-quality energy carriers, the per capita energy use rate is expressed in Watts (an abbreviation of Watt-years per year). For wood it is also given in tonnes of dry wood per year, assuming 1 tonne of wood = 18 Gigajoules, so that 1 tonne per year = 570 Watts.

Source: J. Goldemberg, T.B. Johansson, A.K.N. Reddy, and R.H. Williams, Energy for a Sustainable World, World Resources Institute, Washington, DC, September 1987.

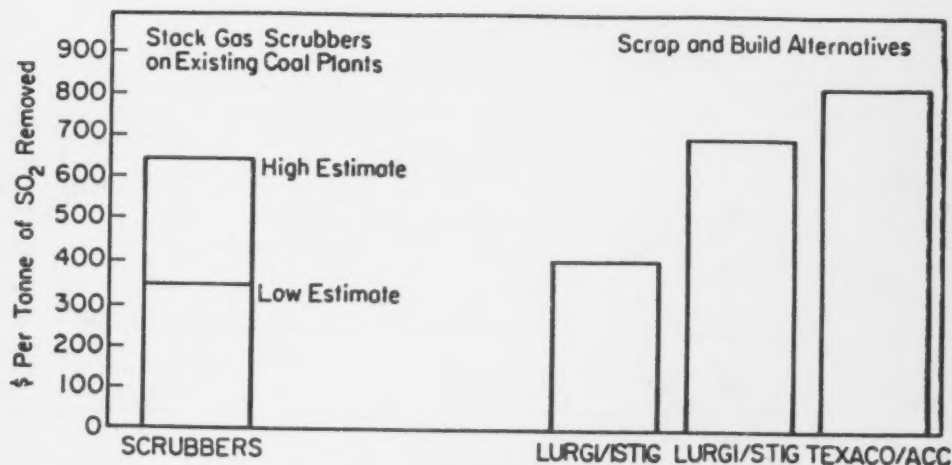


Figure 9.

The cost of sulfur removal with alternative acid rain control strategies for coal with an average sulfur content of 3.1%. The bar on the left shows the range of estimated costs for putting stack gas scrubbers on existing coal steam-electric plants, for capital costs in the range \$193 to \$344 per kW, extra O&M costs in the range 0.42 to 0.83 cents per kWh, a 60 percent average capacity factor, and 85% sulfur removal. The three bars on the right are for cases in which existing plants are retired and new coal gas-based gas turbine plants are built at these sites, allocating all the incremental cost to sulfur removal, assuming 95% sulfur removal with coal gasification. All the cost and performance characteristics for the new plants are from [6], except that capital costs are reduced 10 percent because some of the existing facilities can be used in the new plants. In taking credit for the operating costs of the retired plants, it is assumed that the efficiency of the existing plants is 33.2 percent, the average for coal plants in the U.S. in 1985, and that the O&M cost for the existing coal plants is 0.38 cents per kWh, the average for Midwest coal plants without scrubbers. A 6.1% discount rate and a 30-year lifetime are assumed for all cases.

The major cost uncertainty for the CIG/ISTIG option is the cost for the chemical hot-gas cleanup system. The uncertainty in the capital cost of the cleanup system is $\pm 25\%$, or $\pm \$27$ per tonne of sulfur dioxide removed. At the targeted catalyst consumption rate of 0.5%, the contribution of the cost of the catalyst to sulfur dioxide removal is \$41 per tonne. But the consumption rate could be as high as 1% or as low as 0.25%, so that the catalyst cost could range from \$21 to \$83 per tonne of sulfur dioxide removed. Thus, the cost of sulfur removal with Lurgi/ISTIG is probably in the range \$352 to \$469 per tonne, with the most likely value being about \$400 per tonne.

PROGRESS IN a-Si SOLAR CELL TECHNOLOGY VS. CALENDAR YEAR

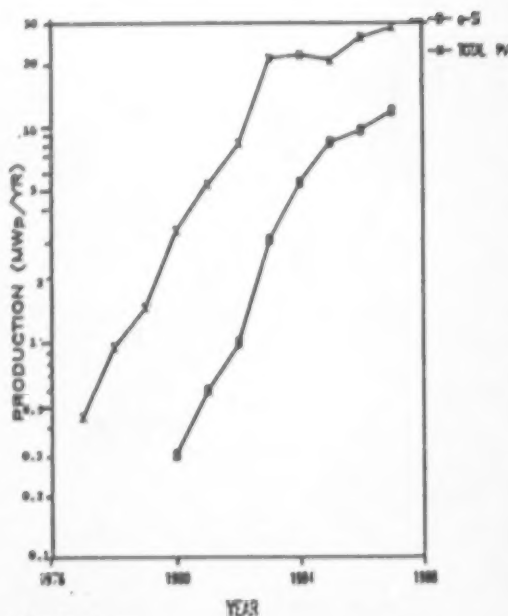
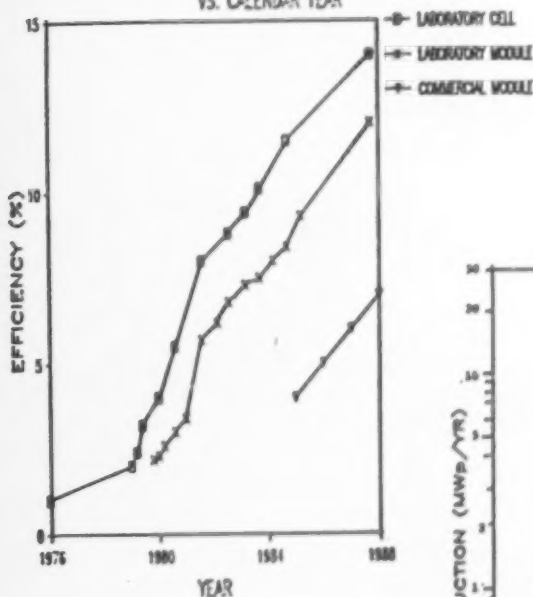


Figure 10.

Progress in Amorphous Silicon Solar Cell Technology.

The trends in the efficiency of amorphous silicon (a-Si) small-area laboratory cells (typically 1 cm x 1 cm in size), larger area laboratory modules (≥ 100 square centimeters), and commercially available modules are shown vs. calendar year in the top graph.

The bottom graph shows the total annual PV production volume and the annual production of amorphous silicon solar modules in megawatts of peak power manufactured per year.

Sources: Y. Kuwano, SANYO, private communications, 1985; Z Erol Smith, private communications, 1987; D. Carlson, Solarex, private communications, 21987; Photovoltaic Insider's Report, February 1987 and January 1988.

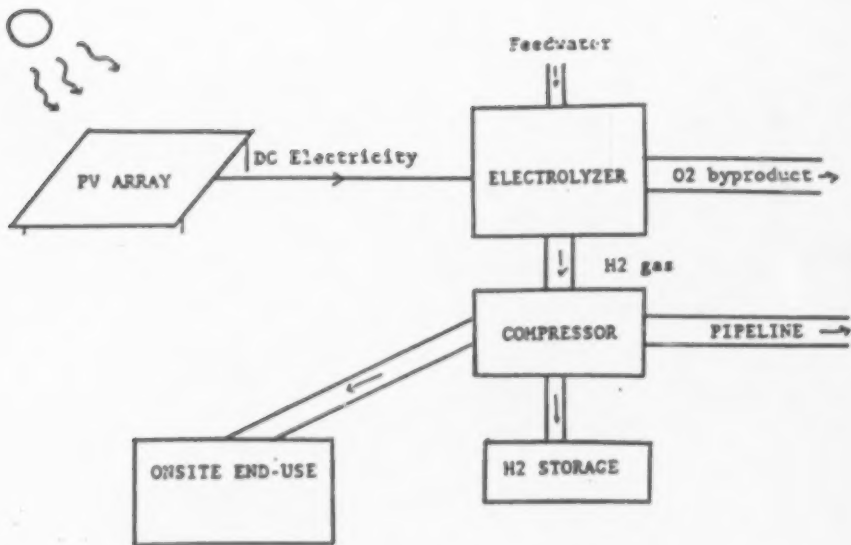


Figure 11.

A Solar Photovoltaic Electrolytic Hydrogen System.

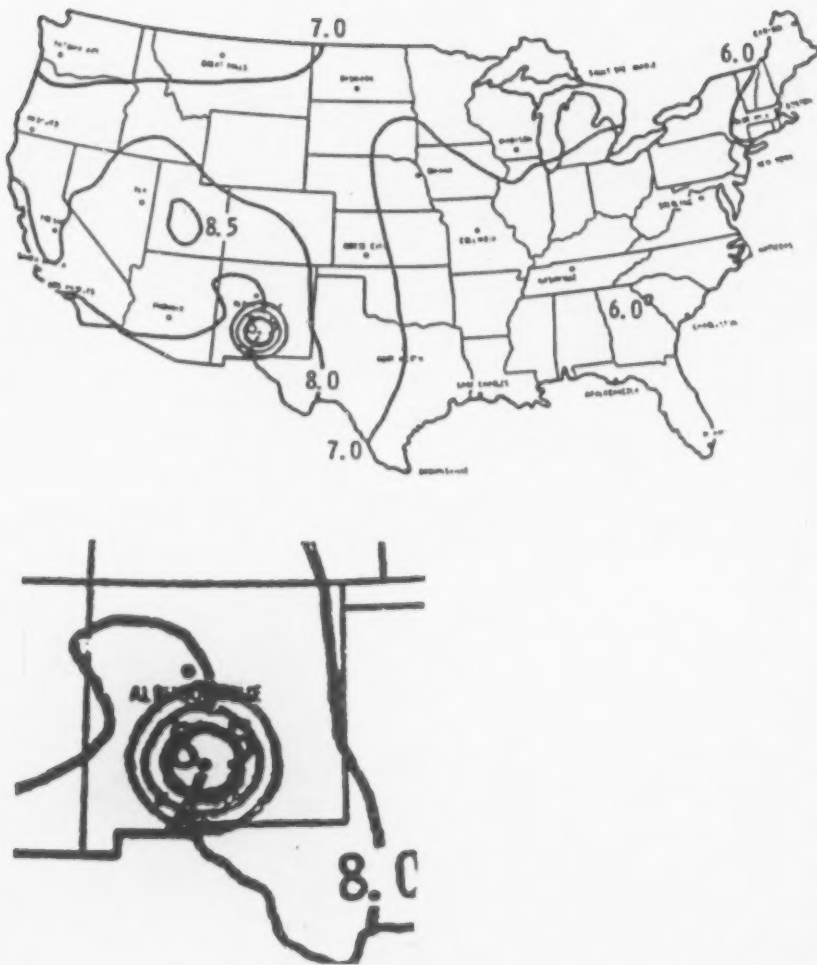


Figure 12.

The Land Area Required to Produce an Amount of PV Hydrogen Equivalent in Energy to 1986 US Oil Consumption, Oil + Natural Gas Consumption, and Oil + Natural Gas + Coal Consumption.

LEVELIZED COST OF ALTERNATIVE FUELLED CARS VS. FUEL ECONOMY

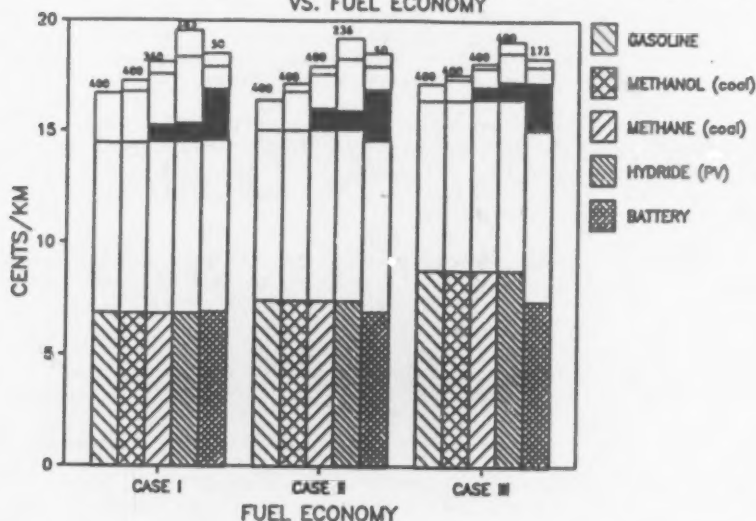


Figure 13.

A Comparison of Levelized Costs for Owning and Operating Cars on Various Synthetic Fuels for Three Levels of Automotive Fuel Economy.

The levelized cost in cents per kilometer is shown for automobiles fueled with gasoline, methanol from coal, synthetic natural gas from coal, electricity stored in batteries, and PV hydrogen. Case I is roughly equivalent to a present day sub-compact car with a fuel economy of 30 mpg of gasoline equivalent. Case II is roughly equivalent to a subcompact car with a more efficient engine (Diesel or stratified charge), with a fuel economy of 50 mpg. Case III, for which the gasoline-equivalent fuel economy is 90 mpg, is what could be achieved in a car with a more efficient engine, aerodynamic styling and a continuously variable transmission. For each case, the levelized cost has four components: initial capital cost of the vehicle (which is shown in hatched patterns and includes the purchase price of the car, exclusive of extra storage system costs), miscellaneous expenses (shown in white above the initial capital cost of the vehicle, this includes tolls, registration fees, insurance, parking, repairs and maintenance), the storage cost (shown in black and includes any extra cost for a special fuel storage system such as batteries, compressed gas cylinders or hydride tanks), and the fuel cost (shown in white at the tops of the bars). The delivered costs of fuels are: \$8.19/GJ (\$1/gallon) for gasoline, \$9.9-\$12.1 per GJ for methanol from coal, \$8.9-\$11.0/GJ for synthetic natural gas from coal, \$0.06-0.10/kwh for electricity, and \$12.9-\$18.0/GJ for PV hydrogen. The numbers at the tops of the bars indicate the travelling range (in km).

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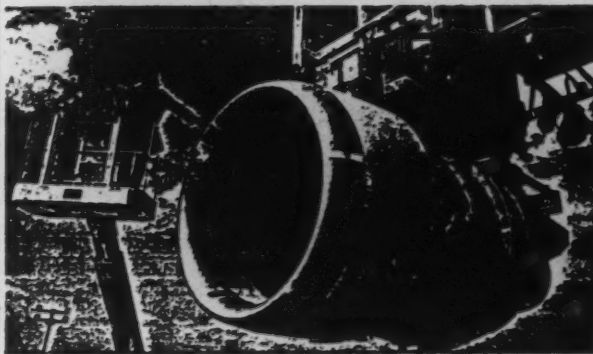
APPENDIX A

They Make Good Things for Flying

GE's turbofans have become the most popular engines in the sky

For all its industrial might, General Electric was treated like a pip-squeak when it first entered the macho business of building commercial-jet engines. Two decades ago, when a GE representative tried to sell a new engine to Donald Nyrop, then president of Northwest Airlines, the executive pointed to a ceiling fixture and wisecracked, "Whenever I want a light bulb, I'll pick GE's. For jet engines, I'll stick with Pratt & Whitney." Nearly all jet airliners built at that time, notably the long-range Boeing 707 and shorter-haul McDonnell Douglas DC-9, were powered by engines carrying Pratt & Whitney's eagle emblem. GE, despite suc-

rently a popular engine for jumbo jets, was derived from a design initially developed in the late 1960s for the Air Force's giant C-5A cargo plane. The engine was the first to use a high-bypass technique in which a fan, working like a turbocharger in an automobile, pushes large quantities of air past the combustion core to produce much greater thrust. The CF6 turbofan (current cost: \$6 million each) has broken the hold Pratt & Whitney had with its JT9D on the giant Boeing 747. GE has boosted production of its most powerful version, the CF6-80C2, from 110 engines in 1987 to 260 this year to meet a backlog of nearly 500 orders.

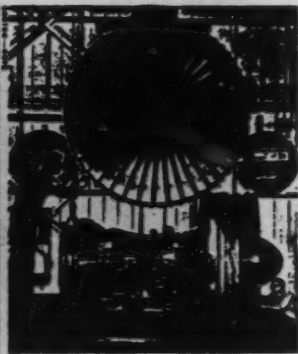


The most powerful GE product, a CF6-80C2, gets a final check before testing at an Ohio plant.

the verge of withdrawing its support.

The CFM56 has no real rival, because Pratt & Whitney scuttled its plans to build a similar model. The engine builder, a division of Connecticut's United Technologies, cut development plans in the 1970s under the parent company's acquisitive chairman, Harry Gray. "Instead of building this engine, Gray bought Otis Elevator. It was a monstrous mistake," says Wolfgang Demisch, who follows the industry for the Union Bank of Switzerland. The company later suffered "a market-share erosion as severe as any I can bring to mind," said Demisch.

Four years ago, Pratt & Whitney helped form a five-nation consortium to produce a competitor to the CFM56, but that effort has been plagued by setbacks. The partnership initially claimed that the new engine, called the V2500, would be



Pratt's challenger, a PW4000, in Connecticut.

cess in developing high-thrusting jet engines for the military, ranked a distant third after Pratt & Whitney and Britain's Rolls-Royce in selling the more fuel-efficient engines needed for passenger planes. Admits Brian Rowe, 56, the burly head of GE's Ohio-based aircraft-engine group: "When we first debbled in commercial engines, we got burnt badly."

GE persevered, and is now the world's dominant engine builder by a commanding margin. Last year GE captured an estimated 63% of the market, compared with 27% for Pratt & Whitney and 10% for Rolls-Royce. The company's success is a classic lesson in the value of patience and persistence, as the design of a new jet engine is a devilishly long-term process that can consume at least five years and more than \$1 billion. GE took a more astute aim at the aircraft market of the future, while Pratt & Whitney failed to develop a full range of quieter and more fuel-efficient models. GE's strategy is paying off. Last year its aircraft-engine division earned profits of \$940 million on revenues of \$6.8 billion.

Basically, what GE did was to painstakingly refine its military designs into a line of passenger-jet engines. Its CF6, cur-

GE has also produced more than 2,000 of its smaller CFM56, the industry's current top seller. The compact engine is well suited to the new generation of shorter-range planes, like Boeing's 737-300, which airlines are using on their growing number of hub-and-spoke routes. The core of the CFM56, originally a top-secret design intended for the B-1 bomber, was the most advanced available.

Even more daring was the decision by GE to team up with a foreign rival, France's SNECMA, to design and produce the engine. Their partnership, the first of its kind, arose in 1971 from the friendship between two old soldiers: SNECMA's chairman René Ravaud, a crusty, one-armed hero of the French Resistance, and GE's chief enginemaker Gerhard Neumann, who had served as ground-crew chief for the Flying Tigers in China. Each company brought a key ingredient to the partnership: GE shared its high-tech engine core, while the French firm contributed financing from its government. Yet, says Jean Bilien, head of the partnership's marketing company, "for nearly five years we had an engine but no buyer." The partners won their first contract just when the French government was on

14% more fuel efficient than its GE counterpart, but that estimate has been scaled back to 9%. Moreover, the V2500 lost a major customer in February, when West Germany's Lufthansa, citing technical flaws, canceled an order for 40 engines and turned to the CFM56. Now Pratt & Whitney is staking its comeback on its new large engine, the PW4000, for which it has won orders from Singapore Airlines and Korean Air. Says Selwyn Benson, head of the firm's commercial-engine division: "Two-thirds of the \$60 billion in new sales over the next ten years will be in that segment of the market."

GE is betting heavily on a radical-looking new engine called the UDF, for "unducted fan." With 16 curved fan blades that spin in the open air, the engine looks like a food processor but produces a fuel saving of 40%. McDonnell Douglas has flight-tested the UDF on the prototype for its next midrange plane. But perhaps GE's moment of poetic justice really came last May, when Northwest Airlines, the diehard Pratt buyer, decided to buy 120 of the CFM56 engines. That must have prompted a few smiles at the light-bulb company. —By Frederick Hughes/News Week

Gas Turbine World

SERVING INDUSTRIAL AND ELECTRIC UTILITY POWER ENGINEERS

ENGINEERING NEWS AND TRENDS

New NOx and CO limits spark utility industry interest in "I-STIG"

Strict new emission control regulations proposed for southern California have sparked utility interest in the economic and environmental benefits of replacing existing capacity with intercooled steam-injected gas turbines (I-STIG) for electric power generation.

South Coast Air Quality Management District (SCAQMD) has proposed two rules which if enacted into law will have far reaching impact on existing and new plants of all types including gas-fired and oil-fired boilers (for steam plants) as well as gas turbines.

Proposed Rule 1134 establishes NOx emission concentration levels for new and existing gas turbines targeted at 9 ppm NOx for new installations and 12 ppm for retrofits. Rule 1135 establishes short term NOx emission levels for new and existing boilers targeted at 0.03 ppm/MMBtu of boiler fuel.

Preliminary hearings have already been held for airing industry comment and discussion. A final formal meeting is scheduled for early January 1989 to consider new testimony and recommended amendments prior to adopting final ruling for legislative action.

Compliance will require rather hefty investments. Several actions for compliance are being considered by electric utilities in the South Coast Air Basin in anticipation of the rules being made law essentially as proposed.

These include retrofitting existing steam boilers with selective catalytic reduction (SCR) for NOx and CO; retrofitting gas turbine installation for SCR operation (simple cycle as well as combined cycle plants); substituting methanol as a boiler and gas turbine fuel; shutting down and replacing old plants with new generating capacity that will meet the new emission requirements.

Billions of dollars are involved. Southern California Edison, for example, has upwards of 6000 MW in gas-fired capacity on its system. Plans to retrofit 31 plants with SCR reportedly would cost in the neighborhood of \$1 billion just to modify existing capacity without any improvements in efficiency or extension of plant life.

Some planners recommend going to I-STIG. One alternative which SoCalEd is exploring is to shut down and replace the generating capacity now in service with I-STIG plants which operate at over 50% efficiency with extremely low NOx and CO emission levels.

At a projected cost of \$400 per kW installed (in today's dollars) the utility is looking at something like \$2.4 billion to replace 6000 MW. But the new plants could be built on existing sites without having to enlarge or build new stations.

Fuel savings more than offsets capital costs. At 50%-plus efficiency the fuel savings reportedly would more than offset the cost of the new generating capacity — at far lower net emission levels than the same amount of MWs replaced even if equipped with SCR.

The big problem is whether or not I-STIG can get down to the 9 ppm NOx target level. That remains to be proven. But even if I-STIG can only get down to 12 or 15 ppm NOx, advocates argue, there is still a net improvement in the environment over SCR equipped plants that are not nearly as efficient.

I-STIG proposed at California Energy Commission hearing in November

A California Energy Commission (CEC) hearing was held last November 22nd to consider revising utility resource plans for meeting energy needs through the end of this century.

Hearing focused on the SoCalEd system where more stringent emission restrictions proposed by SCAQMD under present guidelines would require SCR for existing boiler and gas turbine plants.

CEC technical staff suggested it might make more sense to find interim ways of meeting emission requirements — so that when systems like I-STIG become available (in 4-5 years) they could be phased in to replace existing equipment.

Cost effective for SCE to add 5700 MW of I-STIG. Ross Miller of CEC's Development Div. reviewed several studies of the SoCalEd system. One, based on including I-STIG as an option, showed a production cost savings that made it cost effective for SoCalEd to add 5700 MW of I-STIGs by 1999 — an amount 3700 MW above load and reserve requirements.

Natural gas use actually decreased 10 percent by 1999 based on the I-STIG scenario, he said, and total emissions decrease by 30 percent "without the use of SCR." Several different scenarios were also discussed as interim solutions and alternatives which would result in total NOx emissions ranging from 9167 tons/year to 2905 tons/year (68% reduction).

Miller completed the formal presentation by making three main recommendations. For one, "The Commission should reconsider the fuel diversity policy relative to its impact on the potential of gas-fired technologies to improve system efficiency, reduce costs, and reduce emissions.

Secondly, "The Commission should promote and support the R&D of emerging gas-fired technologies for commercial application in 1994 or sooner" as a good way to assure air quality compliance.

Thirdly, "The Commission should take an active role in encouraging the SCAQMD to adopt a more comprehensive approach to air quality compliance. The role that advanced gas-fired technologies might have in such strategies should be investigated."

Formal hearing presentations followed by active question and answer period

During lengthy "question and answer" session that followed, representatives from such companies and organizations as the Independent Energy Producers Assn, Independent Power Corp., California Energy Co., SoCalEd, Southern California Gas Co, and Lutz Intl. (a solar energy firm) sought more details of the staff methods and assumptions.

Asked why CEC was so optimistic about I-STIG, one staff member said the outlook came from contract work on steam injection concepts with Pacific Gas & Electric and General Electric. "We feel the new systems would be considerably more efficient and would meet existing requirements for both boilers and gas turbines.

"We looked at the cost of SCR and, based on a small capacity factor, it didn't make much sense. SCR makes more sense for high capacity units because you can regain some of the capital costs.

"For a low capacity factor it is better to put money in fuel (i.e., a low-emission fuel like methanol) rather than capital costs — and later replace (with equipment) with advanced gas turbines when they become available."

Staff members also observed that the advanced gas turbine technology in question "is just in its infancy. There are a host of future improvements that can enhance their ability to offer still a better choice. Even I-STIG, a good choice, offers still better performance [later on]."

A spokesman for Independent Power Corp. asked about the staff's suggestion that some 5700 MW of SoCalEd's capacity were candidates for future replacement. Miller replied, "We added on a block of I-STIGs and ran a cost model on savings because of more efficient dispatch than older units. We kept adding [these units] until it was no longer cost effective — and it turned out to be at 5700 MW."

I-STIG ability to meet 9 ppm NOx without SCR addition questioned

Some of the audience wondered about the ability of I-STIG systems without SCR to meet NOx levels established by the district of 9 or better. Particularly since reducing NOx tends to increase CO output.

Gerry Demis, a staff member, responded that "I haven't seen any vendor guarantees at the 9 ppm level. It may be, to meet low NOx levels, you may need a CO catalyst, but that's much less expensive than SCR." (It was indicated, though, that GE does feel current I-STIG technology can be fine-tuned to achieve or come close to 9 ppm NOx.)

General Electric reported on status of "STIG and I-STIG" engine designs

Michael Horner, manager of industrial development programs at GE's Aircraft Business Group, Cincinnati, Ohio, outlined the current status of the company's STIG and I-STIG programs.

Horner stated that with high pressure gas turbine designs you can run steam through the engine so it acts as its own steam turbine. When steam is brought in with natural gas fuel it lowers the flame temperature and so cuts NOx output.

"In recent tests we found that if we were careful in adding steam, we can shift the CO curve to the right and get both low NOx and CO." (Other gas turbine manufacturers have suggested the combination of dry low-NOx combustor designs combined with steam injection would also reduce both NOx and CO.)

He noted that operating experience to date has been only on steam-injected gas turbines. But lab and theoretical studies show significant potential for the addition of intercooling.

Compared to the LM5000 simple cycle machine, he stated, an LM8000 I-STIG cycle (derived from the CF6-80C2 aircraft engine) would give you almost four times the output — go from 36 MW to 114 MW. It will also give you 52% efficiency compared to 36% for the simple cycle LM5000 and 42% for the STIG version."

He continued, "Why invest in this technology? Not only do we start off with a low-NOx high-efficiency system but we can go further. The LM12000 (follow-on design) will...get into 60% efficiency and above in the future — with pretty much the same core engine."

Operating prototype would take 4 years to develop. Horner told the hearing that significant improvements can be made over I-STIG's introductory performance. These have been identified, he said, but would be premature to consider until the technology moves ahead.

Horner stressed that the technology for an I-STIG design is all proven and available for application to an engine design. He estimated that if the I-STIG program gained necessary support, it would take about four years of design development "to do modifications of the low-pressure system and some other minor changes to develop an operating prototype."

In response to a CEC query about emission levels, he replied, "GE currently guarantees 25 ppm NOx for STIG versions [without intercooling] of the LM5000. We have gotten down to 10 ppm on one installation but would need to do a lot more testing at different conditions before we could give a 10 ppm guarantee."

He indicated that the design engineers have some ideas on I-STIG and the way it is put together to significantly reduce NOx further. CEC then asked when he thought GE would have hard information on NOx performance. Horner said "we hope to have the needed data in the next six months."

IPPs expressed interest in both "STIG" and "I-STIG" power generation

A spokesman for Independent Power Corp. noted that independent power producers have pioneered a number of advances in new generating technology. He indicated that a number of people in the field are interested in both STIG and I-STIG concepts.

Would take \$100 to \$150 million to launch an I-STIG design program

He observed that some IPPs might want to pioneer the use of I-STIG even in advance of the utility industry. And then asked when they could realistically consider and propose such a plant for utility service.

Horne's response was that "STIG is already avail-

able. I-STIG depends on the availability of \$100 to \$150 million to pave the way for installation of the first unit. We cannot plan on developing I-STIG without a clear signal there's a market available."

He had pointed out earlier in his formal presentation that GE thought such financing might take the form of the "launch-order" concept used in the commercial aircraft industry.

Under this approach "the manufacturer makes a commitment to provide equipment with certain specifications based on a launch order by the users for a specified number of units with a scheduled series of progress payments in advance."

The users, in turn, are committed to buying a minimum number of units. It also allows the users to have a voice in specifying design features important to their intended applications.

General Electric's I-STIG designed around CF6-80C2 aero core engine

GE proposes to design the LM8000 I-STIG around its CF6-80C2 aero core engine. Preliminary performance analysis shows it would be able to generate 14 MW — nearly 3.5 times the output of a simple cycle LM5000 and more than 2 times the output of a steam-injected LM5000.

The only additional hardware needed for an I-STIG system compared to a simple cycle gas turbine, says GE, are a heat recovery system generator (HRSG), a compressor intercooler, and a water treatment system.

In written commentary to CEC prior to the hearings, GE compared I-STIG performance to simple cycle and STIG cycle LM5000 designs (also based on CF6 aero engine) as tabulated below.

Further improvements in cycle thermal efficiency and output are possible in growth versions of the LM8000, GE pointed out, such as increased firing temperature, incorporating the CF6-90EI core (under development), reheat combustion, chemical recuperation, and others.

Design/Performance	LM5000 Simple Cycle	LM5000 STIG Cycle	LM8000 I-STIG Cycle
Net plant efficiency	37 percent	42 percent	52 percent*
Output	36,000 kW	51,400 kW	114,000 kW
HP compressor air flow	272 lb/sec	309 lb/sec	353 lb/sec
HP compressor outlet temp	971°F	1053°F	726°F
HP compressor outlet press	394 psia	470 psia	500 psia
HP turbine inlet temp	2110°F	2150°F	2500°F
Pressure ratio	26.6	32	34
Steam flow	0	36.7 lb/sec	60.5 lb/sec

*Guaranteed efficiency. Average engine plant thermal efficiency 53.9%.

Turbo Power Marine and Rolls-Royce also have advanced "I-STIG" expertise

Although neither Turbo Power Marine nor Rolls-Royce presented testimony at the CEC hearing, both companies are known to have expressed interest in proposing their own I-STIG design development programs.

Industry observers point out, however, that General Electric is the only one of the three with expertise in STIG plant design and operation — and is favored to lead the way with its LM8000 design.

But the technology is available to all and they do have the in-house expertise to field competitive designs also based on advanced aero core engines.

GRI teaming up with GE on steam injected LM 1600 design

General Electric MIED and the Gas Research Institute are participating in a cost-shared program to develop a steam injected LM 1600 for cogeneration applications.

Project is in the Phase 1 preliminary design stage with reference engine built around the LM 1600 gas generator and new 2-stage power turbine design developed by Ruston Gas Turbines.

Phase 1 Gas generator design mod. Design development engineers are concentrating on the gas generator modifications needed to handle the increased mass flow that steam injection produces.

Also evaluating tradeoffs between improved heat rate, increased output, capital costs, emissions and operational reliability. Project timetable calls for field test of STIG LM 1600 production prototype by the middle of 1990.

General Electric is already out looking for an industrial sponsor for the first unit — for installation at the host's site.

Boost output 30% with 13% reduction in heat rate. Preliminary performance estimates for the steam injected LM 1600 show power can be increased some 30% — from 13 MW ISO base at the generator terminals to 17 MW — and a 13% improvement in heat rate from 9744 Btu/kWh to 8500 Btu.

That is equivalent to a 5 point improvement in thermal efficiency which goes up to 40% from 35%. Mass flow increase by about 20 lb/sec — to 120 lb/sec — while the exhaust temperature drops from 912°F to 830°F.

Steam for injection leaves less for process. Quoted performance improvement for the LM 1600 requires HP and LP steam injection. At the 17 MW base load rating, talking about a steam injection rate of 20,700 lb/hr of high pressure steam at 450 psia/760°F plus 28,400 lb/hr of low pressure steam at 190 psia/720°F.

The HP steam is injected through the fuel nozzles for

NOx suppression and also into the compressor discharge at the combustor for power augmentation. In addition, LP steam is injected into the transition duct ahead of the power turbine for supplementary power augmentation.

Fully steam injected LM 1600 for continuous base load output performance requires roughly 20,000 lb/hr of high pressure steam and 28,000 lb/hr of low pressure steam. Rest is available for process.

Calculations for a STIG LM 1600 exhausting into a dual pressure level unfired HRSG show typical HP and LP steam flow produced available for steam injection and process.

HP Steam Flow	Pressure	Temp
52,000 lb/hr.....	600 psia	400°F
47,000 lb/hr.....	600 psia	600°F
40,000 lb/hr.....	600 psia	800°F
LP Steam Flow	Pressure	Temp
55,000 lb/hr.....	200 psia	400°F
49,000 lb/hr.....	200 psia	600°F
45,000 lb/hr.....	200 psia	800°F

Senator WIRTH. Dr. Williams, thank you very much.
Mr. Cavanagh.

**STATEMENT OF RALPH CAVANAGH, SENIOR ATTORNEY,
NATURAL RESOURCES DEFENSE COUNCIL**

Mr. CAVANAGH. Thank you, Mr. Chairman.

I am appearing this morning on behalf of the Natural Resources Defense Council, the Environmental Defense Fund, The National Audubon Society, and the Union of Concerned Scientists. These groups have more than 800,000 members nationwide, and they have been among the leaders in the public interest community finding solutions to national energy problems.

I should also note, Mr. Chairman, that since 1979, I have directed NRDC's energy program, and I have been spending most of my time over that decade involved in collaborative projects with utilities and state regulators to develop the promise of conservation as a resource, as a source of kilowatt hours and therms and barrels of oil in its own right, the functional equivalent or better of new power plants, new oil fields, new gas fields.

I am particularly glad to see Senators McClure and Burns here because I learned the energy business in the northwest, and I know you share my pride in seeing many of the successes and the experience of the northwest region reflected in S. 324.

I want to note in particular in terms of leadership on energy conservation, development and investment, the role and the contributions of the Pacific Power and Light Company and the Bonneville Power Administration, representing both private and public sectors, both of which will be appearing before you later today—and I don't know how often they have been praised publicly at Senate hearings by representatives of environmental groups, but I am sure there will be many other occasions in addition to this one. And I enjoin you to pay particular attention to their testimony.

I want also today, on behalf of the groups that I just mentioned, to endorse S. 324 and to thank you, Senator Wirth, for your leadership in introducing and pressing forward with it. I want to mention just two points from my testimony in support of your bill.

The first goes to the reasonableness of the near-term goal of a 20 percent carbon dioxide reduction as something that national energy policy should aspire to accomplish. The question is whether that is something we can reasonably aspire to do.

By way of support for that proposition, we went and took a look at seven major energy efficiency strategies that we knew how to model and project forward at this time to determine what their impact would be on carbon dioxide emissions assuming the sustained economic growth that we all hope for. Those strategies are spelled out in detail in our testimony, Senator Wirth, and we have determined that just based again on what we know how to analyze—and it is far from a complete assessment of energy efficiency opportunity—we can get three-quarters of the way to your goal by the year 2000 and past it by the year 2005. And that strongly suggests to us that you certainly haven't set your sights too high as an initial proposition.

We also wanted to say a special word in support of title I of this bill, which sets out something called a national least-cost planning process. And that very phrase tends to evoke certain reactions, some of them far from complimentary, the first being why on earth do we have to mandate something that everyone obviously would jump at in any event, namely, least-cost planning; and second, somewhat paradoxically, a rather different reaction which shies back at the very term and says isn't this a thinly veiled effort at centralized economic planning which is totally foreign to the ideals and experience of this country.

And let me try to respond to both of those in the context of something that speaker after speaker has called for in this hearing, previous hearings, and I am sure will call for in subsequent testimony before you all. You are going to hear everyone asking for a comprehensive national energy policy. You are going to hear it from the Secretary of Energy who has already said that is one of his central goals. And I know that is something that many of you feel strongly that we have fallen away from in the past eight years.

The problem is that there is no consensus whatever on what comprehensive national energy policy should look like. And what we really need now is an open public process that is capable of creating a consensus around where we should go. We had that problem in the northwest, as Senators McClure and Burns recall, a decade ago, and the response was for the Congress to set up, again, an open forum in which all of the alternatives for meeting energy needs, both efficiency alternatives and production alternatives, could compete on equal terms for public resources, both regulatory resources and financial resources. And out of that process, we were able to wring from all of the different contentious interest groups the kind of consensus we could never have got if our effort had simply been to impose from the outset some single interest group's preordained and preconceived notion of what energy policy should be.

In your least-cost energy plan, you have created and spelled out in great detail a rigorous way to let conservation and production alternatives, again, compete on equal terms for the dollars and resources of the Federal Government and of other sectors which cumulatively make up the energy investment of this country. And the effort isn't to mandate from Washington. The effort is rather to identify obstacles to the free-functionings of markets that normally ensure least-cost energy solutions and to get those obstacles out of the way. If we need an analogy here, it is to dredging away the obstacles to least-cost energy planning solutions and not to replace markets with some kind of centrally planned and mandated set of solutions.

It is I think in that spirit that the least-cost planning title is offered. I can tell you it has worked in the northwest. I can tell you that the Electric Power Research Institute has determined that 43 states are now using or actively exploring it which hardly suggests that it is some kind of thinly veiled excuse for central economic planning.

I want to close, Mr. Chairman, on a note of urgency and a note of hope. The note of urgency stems from the fact that we are—

there are all sorts of signs right now that we are losing momentum on energy efficiency and carbon dioxide reductions in this country.

From 1973 to 1986, we achieved something quite extraordinary. We increased our gross national product by more than 35 percent, yet we didn't increase our energy consumption and we didn't increase our carbon dioxide emissions. And that was an extraordinary achievement which I think all here have in the past alluded to.

But we should not today indulge in a great deal of self-congratulation because over the past two years, trends in consumption have moved decidedly upward again. In 1987, we lost all of the progress on carbon dioxide emissions that we had made from 1973 to 1986. Total emissions of carbon dioxide in this country actually increased by 3 and a half percent in just that one year, and the strong growth trend has persisted through 1988.

What kind of international example does that set? What kind of bargaining position does that put American leaders in who are trying to get policies like those of S. 324 adopted by other countries?

That is a reason for urgency underscored by the pervasive barriers to cost-effective efficiency improvements and conservation that continue to impede the measures I have been discussing at every level of this economy, the extraordinary gap between the investment perspectives of conservers and investors in large energy production facilities that continues to be a problem in this country. And that is documented extensively in my testimony, and you will hear more about it this afternoon.

Of at least equal importance, if I can foreshadow my utility friends this afternoon, is the problem in the state regulatory system where utilities' investment in energy conservation in 49 of our 50 states right now is inherently unprofitable to the utility, and it gets more unprofitable the more successful a utility's program is.

Senator Burns, I have just signed an agreement with the Montana Power Company in Butte, Montana where they are going to invest \$100 million in energy conservation over the next decade not because it is ideologically attractive, but because they view it as a less expensive source of new energy supply than the alternatives.

But I think that as a representative of the consumer side of the utility equation, that I owe it to them and that my organizations owe it to the utility industry to make sure that there are financial incentives in place so that they get rewarded if they do a good job. Now, this bill doesn't try to mandate any particular solution for the states. It simply asks the state regulators within two years to take on and solve this problem. And I think that is an important contribution that the bill makes. But the very existence of the problem, the very fact that in 49 of 50 states it is unprofitable for a utility to invest in energy efficiency at the present time, that underscores the extraordinary barriers to energy efficiency that we have to overcome if we going to meet this bill's goals.

I promise to close on a note of hope. The note of hope is that although the environmental challenge you face today is as daunting as that of—that any of your predecessors ever imagined, you have one advantage. Back in the late 1960s and early 1970s, when Con-

gress took on the air and water pollution problems in a serious way for the first time, we didn't know what the technical solutions would be. The Congress was in a position literally of having to ask for solutions and hope they would emerge over the course of the decade ahead. And fortunately, in most cases they did.

The advantage we have here, as you have already heard from several witnesses, as you will hear from many more, is we know technically how to solve this problem. The issue is rather one of summoning the national will to do what we already know how to do on a national basis and to set the kind of international example that can then lead other nations to follow us.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Cavanagh follows:]



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THE NATIONAL ENERGY POLICY ACT OF 1989

TESTIMONY

OF

RALPH CAVANAGH

ON BEHALF OF

NATURAL RESOURCES DEFENSE COUNCIL
ENVIRONMENTAL DEFENSE FUND

BEFORE THE

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

MARCH 14, 1989

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SUMMARY: TESTIMONY OF RALPH CAVANAGH, NRDC, ON S. 324

Throughout much of 1988, the nation and its legislators complained bitterly about the weather. By enacting S. 324, Congress can begin the difficult process of doing something about it. Taken individually, this bill's provisions on least-cost energy planning, energy efficiency and renewable energy resources make good sense for American businesses and consumers; taken together, they would help this and other nations begin the urgent task of reducing the threat of global warming.

The sponsors of this bill recognize the need to build a national consensus around priorities for meeting national energy and environmental goals at minimum cost to society. Under the least-cost planning inquiry described in Title I, winners and losers would emerge on the merits. Energy conservation and production options would compete on equal terms for access to the public's regulatory and financial resources. This is a welcome relief from the indiscriminate pork barrel doles that dominated energy policy in the 1970s, and from the more recent philosophy that the best energy policy is to have none.

S. 324 sets a goal of reducing current carbon dioxide emissions by at least 20% at the turn of the century; our testimony provides a strong technical showing that this target is feasible. NRDC scientists' initial assessment indicates that seven major but far from exhaustive efficiency programs alone can get us three quarters of the way to the 20% reduction by 2000 (and past it by 2005), assuming sustained economic growth. The programs include improved fuel efficiency standards for automobiles and light trucks, renewed mass transit support, and selected residential, commercial and industrial improvements.

The price of continued inaction on energy policy will be very high. The point is underscored by the recent loss of U.S. momentum on energy efficiency. We could proudly say in 1986 that both energy use and CO₂ emissions were down from levels recorded as far back as 1973, but 1987 pushed both total use and carbon dioxide emissions back above 1973 levels, and strong growth trends continued into 1988. This reflects not only reduced fuel prices, but also a virtual dismantling of regulatory and financial incentives to conserve at both federal and state levels. Painfully familiar illustrations include:

- o Four consecutive rollbacks of federal fuel efficiency standards from 1985-1988 by the Department of Transportation;
- o Proposed appliance efficiency standards from the Department of Energy that refuse even to consider capturing two-thirds of the potential for cost-effective savings;
- o Rules on utilities' acquisition of power supply from the Federal Energy Regulatory Commission that barely mention energy conservation and fail utterly to ensure it equal competitive opportunity with power plants;
- o Reductions in inflation-adjusted federal research and development budgets for conservation and renewable energy resources of 70-80% during the last Administration;

- o Multi-year delays at the Department of Energy in adopting efficiency standards for commercial buildings constructed for the federal government, followed by the promulgation of grossly inadequate standards (that, for example, defer until 1993 lighting efficiency standards that California has been enforcing since 1987);
- o Deep cuts in energy conservation budgets by many of the nation's electric and gas utilities, and a return to promotional policies designed to boost sales volumes by a total of at least 35,000 peak Megawatts (the equivalent of 43 Shoreham-sized nuclear power plants); and
- o State regulatory systems that almost universally make selling electricity and natural gas much more profitable than saving them, with entirely predictable impacts on management and staff priorities.

All of these factors reinforce what is already a potent bias toward consumption, and against efficiency, throughout the energy marketplace. As documented in our testimony, this bias leads prospective investors in efficiency routinely to decline or ignore opportunities with returns far better than those that production facilities can earn. To remove these obstacles, and related market barriers that afflict sponsors of renewable energy resources, we recommend:

(1) Better use of existing federal regulatory and budgetary authorities, including but not limited to ending rollbacks of fuel efficiency standards; improving proposed efficiency standards for refrigerators, freezers and televisions; insisting on full integration of energy conservation resources into utilities' bidding systems for new electricity supply; and requiring utilities, when comparing the costs of their future conservation and generation options, to take account of likely increases in the cost of carbon dioxide emissions. The Department of Interior should stop leasing oil resources in sensitive offshore and Alaskan regions, including the Arctic National Wildlife Refuge, pending the thorough assessment of alternatives that S. 324 would set in motion. And Congress should substitute significant funding increases for the Reagan Administration's proposed cuts in conservation and renewable energy budgets for Fiscal Year 1990;

(2) Enactment of S. 324, including amendments that substantially increase the current statutory ceiling on fuel efficiency standards; and

(3) Further legislative action to promote cost-effective efficiency improvements and renewable energy applications, including but not limited to depriving carbon dioxide of its status as our most dangerous totally unregulated pollutant. Carbon dioxide emissions should start paying their way, through some combination of fees, emissions limits and mitigation.

TESTIMONY OF RALPH CAVANAGH, NATURAL RESOURCES DEFENSE COUNCIL,
ON THE NATIONAL ENERGY POLICY ACT OF 1989

March 14, 1989

INTRODUCTION

I appreciate the Committee's invitation to testify on "energy efficiency technologies and renewable energy resources as they relate to S. 324, the National Energy Policy Act of 1989." Since September 1979, I have directed the Energy Program of the Natural Resources Defense Council (NRDC). I am also appearing today on behalf of the Environmental Defense Fund (EDF). NRDC and EDF are nonprofit environmental-protection organizations with a nationwide membership of more than 200,000 individuals.

For the past decade, most of my time has been spent developing and implementing least-cost planning strategies for energy systems throughout North America. Over that period, I have served as a consultant on least-cost issues to regulators in nine states and Canadian provinces. I have also participated in the design and management of experimental utility-financed conservation programs for both the residential and commercial sectors, with combined budgets exceeding \$25 million. I have published extensively on energy policy, taught graduate courses on the subject at Harvard and Stanford Universities, and testified frequently before the Congress.

I will not attempt any extended review of the evidence that has driven global warming to the forefront of environmental concerns in this and other legislative bodies around the world. No responsible policymaker can ignore repeated expert warnings of a 3-9 degree Fahrenheit average temperature rise as early as 2030, with significantly larger increases in what we now call "temperate" climate zones. In the ensuing devastation of agriculture, coastal zones and ecological systems it is hard to predict any winners.

Energy consumption is implicated in the growing emissions of all the major "greenhouse gases": carbon dioxide, methane,

chlorofluorocarbons and nitrous oxide. Strategies for reducing carbon dioxide emissions are my principal concern today; increases in such emissions account for about one-half of the projected atmospheric warming, with the increases themselves principally attributable to fossil fuel combustion. The United States is the world's largest emissions source, both absolutely and per capita. While we cannot succeed alone, neither can we abdicate leadership responsibilities without all but ensuring failure.

I. ENCOURAGING SIGNS

For most of the 1970s and the 1980s, conservation dominated trends in U.S. energy consumption. A representative account in the late 1980s marveled that "we use little more energy . . . than we did in 1973, though the population has grown by 34 million, there are 20 million more homes to heat and cool, [and] 50 million more vehicles are on the road."¹ Gross consumption actually declined between 1973 and 1986, although the U.S. economy expanded by more than 30% over that period.² A 1988 Scientific American survey pegged the resulting reductions in the national energy bill at \$150 billion per year.³

These achievements in diminished energy intensity were notable, and serve to underscore the point that energy use can be restrained without sacrificing economic growth or quality of life. Reduced U.S. energy consumption from 1973-1986 also brought reduced emissions of greenhouse gasses, as cuts in

¹U.S. Department of Energy, United States Energy Policy 1980-1988, at ix (1988).

²D. Fitzpatrick, Assistant Secretary, U.S. Department of Energy, Testimony before the Committee on Energy and Commerce, Subcommittee on Energy and Power of the U.S. House of Representatives, at 1 (December 2, 1987).

³A. Rosenfeld & D. Hafemeister, Energy-Efficient Buildings, 258 Scientific American 78, 78 (April 1988).

natural gas and oil use more than offset increases in coal combustion.⁴

Not coincidentally, the same era featured important new regulatory and financial incentives to use energy more efficiently. From 1975-1985, federal law forced a doubling of miles per gallon achieved by new automobiles. California's appliance efficiency standards had become de facto national requirements by the mid-1980s; for refrigerators, the result was a 35% reduction in average consumption compared to a decade earlier.

Throughout the nation, utilities began investing directly in more efficient uses of electricity and natural gas, as an alternative to more expensive sources of additional supply. A simple but powerful new idea swept through the state regulatory community: a kilowatt-hour preserved from waste is functionally indistinguishable from a kilowatt-hour delivered to consumers by a power plant, and improvements in the efficiency of energy use should compete on equal terms with power plants for access to utilities' investment budgets.

The Pacific Northwest pioneered the "least cost planning" methods that allowed utilities to make rigorous comparative evaluations of potential conservation and production resources; now 43 states are using or preparing to use such methods, according to the Electric Power Research Institute.⁵ Three California utilities alone spent almost \$1 billion on efficiency improvements in the residential, commercial and industrial sectors between 1984 and 1986. New England utilities are now gearing up for efforts of equal or greater scale.

⁴The calculation is based on data from U.S. Department of Energy, Monthly Energy Review. U.S. CO₂ emissions dropped by about two percent from 1973 to 1986, assuming CO₂ weightings of 1.73, 1.43 and 1 for btus consumed from coal, oil, and natural gas respectively.

⁵Electric Power Research Institute, Status of Least-Cost Planning in the United States, at 1 (December 1988).

The national environmental community takes great pride in its role in helping to initiate and design these programs. We agree with the recent comment of Mason Willrich, a senior executive of the world's largest investor-owned utility: "[E]nergy conservation is our cheapest, safest and cleanest source of energy supply -- a supply that contributes nothing to global warming."⁶ Attached to this testimony are statements to the same effect from the leadership of the dominant power wholesaler in the Pacific Northwest (the Bonneville Power Administration) and its regulatory body (the Northwest Power Planning Council).

The Committee will hear much today about the remarkable pace of technical innovation in energy efficiency; I want to share one case study that reinforces the point. Drawing largely on its friends in the utility community,⁷ NRDC has raised the funds to commission a prototype frost-free refrigerator that will look and perform exactly like the models now occupying Committee members' kitchens, with one very important exception. Your refrigerators use relatively inefficient insulation that is rich in chlorofluorocarbons, the chemicals that are destroying the ozone layer. Our refrigerator will be insulated with a gel that is completely free of CFCs and has almost three times the insulating strength per inch. This is one more illustration of the point that the best news on energy efficiency is yet to come -- and that we need not sacrifice energy conservation goals in order to make progress on ozone depletion.

Renewable energy resources will also be a crucial part of the transition to an energy future free of the need for massive fossil fuel combustion. Here too the last decade has produced

⁶M. Willrich, "Murder in Acre", at 8 (address delivered in San Francisco, February 13, 1989).

⁷We gratefully acknowledge the assistance of the Electric Power Research Institute, the Snohomish County PUD, the Pacific Power & Light Company, and the Environmental Protection Agency.

grounds for optimism. Where these technologies have had a fair chance to compete against new fossil-fuel generators, they have scored some impressive successes.

A federal law passed in 1978 guaranteed independent small-scale power producers a chance to meet utilities' needs for new generators, if they could produce electricity more cheaply than the facilities that the utilities would otherwise buy. The conclusion that emerges powerfully from this law's first decade is that if independent producers are offered long-term contracts at or near the cost of a new utility-sponsored coal or nuclear plant, enough responses promptly emerge to displace all such plants from acquisition schedules. By 1986, jurisdictions as diverse as California, Idaho and Maine had indefinitely deferred all new coal and nuclear plants by signing up 1424 wood-fired, hydro, wind and cogeneration units with an average capacity of about 12 Megawatts.⁸ Further evidence of competitive progress should emerge from the Worldwatch Institute's ongoing review of renewable energy cost trends, scheduled for completion in the summer of 1989.⁹

II. EMERGING FAILURES IN ENERGY POLICY

If the preceding section seems in part an invitation to national self-congratulation, some very recent developments emphatically suggest otherwise. Sadly, a grim February 1989 headline in the New York Times had it exactly right: "U.S. Progress in Energy Efficiency is Halting." Energy consumption

⁸Idaho and California figures were reported by utilities in response to a Senate inquiry; see generally Implementation of the Public Utility Regulatory Policies Act, Hearings before the Senate Committee on Energy and Natural Resources, 99th Cong. 2d Sess. 58, 114 (1986). Figures for Maine are from Central Maine Power Co., Cogeneration/Small Power Production: Pre-Decrement Through Subsequent Decrement (1986).

⁹For details on the study, contact Chris Flavin, Worldwatch Institute, 202-452-1999.

increases for 1987 pushed both total use and carbon dioxide emissions back above 1973 levels, and strong growth trends continued into 1988.¹⁰ Coal in particular -- easily the worst of the fossil fuels in terms of carbon dioxide emissions -- recorded sharp gains, with consumption up by almost ten percent in the first ten months of 1988 compared with the same period in 1986.

Electric utilities, the nation's dominant coal consumers, increased their annual use of the fuel by more than 75% between 1974 and 1987.¹¹ And as 1988 drew to a close, the energy trade press was writing once again of "soar[ing] sales" and the prospect of "steady consumption growth."¹² An extensive and sobering assessment appears in a recent report by the American Council for an Energy-Efficient Economy.¹³

However, some of our most effective foreign competitors have been doing considerably better. The same New York Times article cited above noted that the Japanese economy was steadily increasing its already formidable efficiency advantage over our own. Lawrence Berkeley Laboratory scientists have noted that "if

¹⁰This conclusion is based on data from the U.S. Department of Energy's Monthly Energy Reports. U.S. CO₂ emissions dropped by about two percent from 1973 to 1986, assuming CO₂ weightings of 1.73, 1.43 and 1 for btus consumed from coal, oil and natural gas respectively. Carbon dioxide emissions rose almost 3.5% in 1987 alone, with coal accounting for 36% of the total (up from 24% in 1973). In the first eight months of 1988, electricity consumption surged by 9.3% compared with the same period of 1986; increases for natural gas and petroleum were 8.7% and 4.8%, respectively.

¹¹Department of Energy, note 1 above, at 79.

¹²Special Report: Annual Industry Forecast, Electrical World (October 1988), at 67-68. See also American Gas Association, Monthly Gas Statistical Report (September 1988) (natural gas industry projects sales volume growth in excess of five percent for 1988).

¹³H. Geller, U.S. Energy Demand: Back to Robust Growth? (ACEEE Energy Efficiency Issues Paper No. 1, February 1989).

the U.S. became as energy-efficient as Japan, this country would consume half as much energy as it does today."¹⁴

Our recent failures to make progress in that direction are not solely a function of reduced fuel prices; indeed, Japanese fuel prices have dropped even faster (in yen) without similar setbacks in efficiency. We have recently seen something close to a wholesale dismantling of regulatory and financial incentives to conserve, at both federal and state levels. Painfully familiar illustrations include:

- o Four consecutive rollbacks of federal fuel efficiency standards from 1985-1988 by the Department of Transportation;¹⁵
- o Proposed appliance efficiency standards from the Department of Energy that refuse even to consider capturing two-thirds of the potential for cost-effective savings;¹⁶
- o Rules on utilities' acquisition of power supply from the Federal Energy Regulatory Commission that barely mention energy conservation and fail utterly to ensure it equal competitive opportunity with power plants;¹⁷
- o Multi-year delays at the Department of Energy in adopting efficiency standards for commercial buildings constructed

¹⁴A. Rosenfeld & D. Hafemeister, note 3 above, at 78. Other nations that are outstripping the U.S. by wide margins in efficiency include West Germany, Italy, Sweden and the United Kingdom. See American Council for an Energy Efficient Economy, *Energy Efficiency: A New Agenda* 43 (1988).

¹⁵The latest rollback appears at 53 Federal Register 39275 (October 6, 1988).

¹⁶See 53 Federal Register 48798 (December 2, 1988); NRDC Comments on the Department of Energy's "Three Products Rulemaking" (January 31, 1989).

¹⁷Federal Energy Regulatory Commission, Notices of Proposed Rulemaking, Docket Nos. RM88-4-000, RM88-5-000, RM88-6-000 (March 16, 1988).

for the federal government, followed by the promulgation of grossly inadequate standards (that, for example, defer until 1993 lighting efficiency standards that California has been enforcing since 1987);¹⁸

- o Reductions in inflation-adjusted federal research and development budgets for conservation and renewable energy resources of 70-80% during the last Administration;¹⁹
- o Deep cuts in energy conservation budgets by many of the nation's electric and gas utilities, and a return to promotional policies designed to boost sales volumes by a total of at least 35,000 peak Megawatts (the equivalent of 43 Shoreham-sized nuclear power plants);²⁰
- o State regulatory systems that almost universally make selling electricity and natural gas much more profitable than saving them, with entirely predictable impacts on management and staff priorities.²¹

All of these actions reinforce what is already a potent bias toward consumption, and against efficiency, throughout the energy marketplace. As demonstrated in numerous studies, this bias leads prospective investors in efficiency routinely to decline or ignore opportunities with returns far better than those that

¹⁸See 54 Federal Register 4538 (January 30, 1989).

¹⁹See Congressional Research Service, Renewable Energy: Federal Program and Congressional Interest, Tables 2 & 3 (March 2, 1988).

²⁰Electric Power Research Institute, Impact of Demand-Side Management on Future Customer Electricity Demand, at 4-13 (October 1986).

²¹The problem is analyzed at length by a former Maine PUC Chairman in Moskovitz, Will Least-Cost Planning Work Without Significant Regulatory Reform? (Least-Cost Planning Seminar, National Association of Regulatory Commissioners, Aspen, CO: revised, June 10, 1988).

production facilities can earn.²² Indeed, energy prices would have to increase on the order of seven-fold to overcome the gap that typically emerges in practice between the investment perspective of conservers and producers.²³

This "payback gap" is an invitation to low-return investments in power plants and oil fields that cost-effective conservation could displace. When those investments are made, everyone loses.

There are many rational explanations for the conservers' seeming reluctance to invest. For example, decisions about efficiency levels often are made by people who will not be paying the ensuing energy bills, like landlords or developers of commercial office space. Many buildings are occupied throughout their extended lifetimes by a series of transient owners or renters, each of them unwilling to make long-term efficiency improvements that would principally benefit subsequent users. Sometimes what looks like indifference to efficiency is the result of inadequate information or time to evaluate it, as all will attest who have ever replaced a water heater, furnace or refrigerator on short notice. Often unassisted "conservation shopping" involves significant time commitments, inconvenience and uncertainty, which understandably are resisted by those whose primary business lies elsewhere.

²²See, e.g., Massachusetts Department of Public Utilities, Decision No. 86-36-F, at 17 (Nov. 30, 1988) (as regards conservation, "market imperfections and high initial transaction costs for individual consumers have led to an inefficient allocation of society's resources"); Alliance to Save Energy, Industrial Decision-Making Interviews: Findings and Recommendations 20 (Jan. 1987) (large industrial customers require conservation investments to repay their costs in two or three years; "[u]nder tight conditions projects may be funded only if they have a payback of one year or less").

²³F. Krause & J. Eto, Least-Cost Utility Planning Handbook for Public Utility Commissioners, Volume 2, at II-9 to II-12 (National Association of Regulatory Utility Commissioners: December 1988).

An additional constraint has been particularly devastating for new renewable energy applications. Throughout the 1980s, energy markets have been dominated by production from gigantic projects that were expensive to build but are relatively cheap to operate. Once a large-scale power plant or oil platform or gas field is in production, the cost of an extra kilowatt-hour or barrel of oil is generally modest compared to that of building a new facility, even if the new facility would be more economical than a new conventional plant. As long as existing conventional capacity remains less than fully utilized, the owners of this capacity generally can underbid sponsors of unbuilt renewable resources, whatever their quality -- particularly if the marketplace assigns no value to reductions in carbon dioxide emissions.

III. REMOVING BARRIERS TO CONSERVATION AND RENEWABLE RESOURCES

The Committee has requested my views on "regulatory changes and incentives, including those contained in S. 324, that would encourage more rapid adoption of energy efficient and renewable energy technologies." Full and enthusiastic use of federal prerogatives already created by the Congress would help, and enactment of S. 324 itself would improve matters further, as explained below. My testimony closes with a list of additional ways to eliminate barriers to cost-effective conservation and renewable resources, and to meet the emissions goals of the proposed legislation.

A. Make Better Use of Existing Federal Regulatory and Budgetary Authorities

Federal agencies are already in a position to make a major contribution to global warming solutions. Gasoline mileage requirements for motor vehicles are the exclusive province of federal authorities, as (with some exceptions) are the regulation of appliance efficiency, some commercial lighting equipment, and mobile home construction. The federal government retains

extensive influence over allocations of scarce capital resources between mass transit and highways. Federal agencies license and regulate what currently are the nation's most important sources of non-fossil electrical generation, hydropower and nuclear fission. Interstate gas and electricity transfers have long been remitted to federal regulation, along with many of electric utilities' resource acquisition activities. Much of our undeveloped fossil fuel reserve lies beneath federal lands.

Immediate opportunities for breaking with eight years of missed opportunities include:

- o The Department of Transportation can reject requests by some elements of the automobile industry for a fifth consecutive year of fuel efficiency rollbacks, and restore the Congressionally-mandated standard of 27.5 miles per gallon;
- o The Department of Energy can revise proposed appliance efficiency standards for refrigerators, freezers and television sets to ensure consumers access to all technically feasible and cost-effective energy savings, as numerous Congressmen, states, utilities and environmental groups have urged;
- o The Department of Interior can halt leasing and development of oil resources in sensitive offshore and Alaskan locations, including the Arctic National Wildlife Refuge, pending the thorough assessment of less costly alternatives that Title I of S. 324 would set in motion;
- o Congress can reject the Reagan Administration's proposed Fiscal Year 1990 budget cuts for research and development on energy efficiency and renewable energy budgets, and adopt instead substantial increases in those accounts.
- o The Federal Energy Regulatory Commission can insist on full integration of energy conservation resources into utilities' bidding systems for new electricity supply.

The FERC rules can take an additional step that would help restore competitive parity for both conservation and renewables. In evaluating competing bids for new power supply, utilities throughout the nation are effectively ignoring costs associated with carbon dioxide emissions. This reflects the fact that, as of 1989, no energy technology's price is in any way affected by these emissions. The United States tolerates no other comparably flagrant and devastating failure to internalize environmental costs.

But no prudent planner would count on an indefinite extension of this oversight. Pressures will mount steadily in Congress for carbon dioxide fees, emissions limits, recapture requirements, or some combination. We may not get them this year, but even near-term inaction is far from certain, and the growing international consensus on the mechanics of global warming virtually ensures that these costs will be internalized long before new energy facilities approach retirement. FERC should respond by requiring utilities, in their evaluation of bids for new power supply, to adjust those bids based on carbon emissions from each alternative.²⁴ Anything less puts ratepayers' pocketbooks at intolerable risk, in addition to environmental quality.

To promote these and other innovative uses of existing federal authority, one of the Congress's most promising options is the subject of this hearing.

²⁴I have argued elsewhere that coal-fired generation should be assigned a penalty of at least 20¢, derived conservatively from the costs of a range of mitigation strategies; conservation, renewables and nuclear bids would not be adjusted, and other fossil fuels would occupy an intermediate position, reflecting the ratios set out in note 4 above.

B. Enact S. 324

The framers of this bill recognized the urgent need to build a national consensus around priorities for meeting national energy and environmental goals at minimum cost to society. Under the least-cost planning inquiry described in Title I, winners and losers would emerge on the merits. Conservation and production options would compete on equal terms for access to public resources. This is a welcome relief from the indiscriminate pork-barrel doles that dominated energy policy in the 1970s, and from the more recent philosophy that the best energy policy is to have none. It is also refreshing, after years of excessive federal budgetary emphasis on nuclear power, to see significant cuts in the bloated research and development budgets for this technology.²⁵

It is crucial, however, to provide dedicated funding for the planning enterprise itself. Current DOE support for all least-cost energy planning functions is less than one million dollars annually, and the Department lacks the expertise and resources to perform such work itself. These can be assembled quickly, but they will require at the very least the \$10,000,000 annual appropriations that appear in H.R. 1078, Congresswoman Claudine Schneider's Global Warming Prevention Act of 1989 (§208(b)).

S. 324 sets a goal of reducing current carbon dioxide emissions by at least 20% by the turn of the century, and some have questioned whether this sets our sights too high. On the contrary, an initial assessment by NRDC scientists indicates that selected efficiency improvements can get us about three quarters of the way to the 20% reduction by 2000 (and past it by 2005), assuming sustained, recession-free economic growth. In other

²⁵About \$250 million annually is now being spent on research and development for advanced nuclear reactors; S. 324 would reduce that amount to \$500 million over three years (§§ 701(b) & 703). This is still out of proportion to S. 324's much more modest investments in promising renewable energy technologies, which should be increased substantially.

words, efficiency strategies can yield a substantially larger economy with substantially lower carbon dioxide emissions.

Our conservation projections are incomplete, in that we have not yet evaluated many important end uses of energy, including much of the transportation, multi-family housing and commercial sectors. Examples of measures that we did analyze include automobile efficiency standards that range up to 60 miles per gallon by the year 2008 (45 miles per gallon for light trucks), the use of mass transit to reduce growth in annual mileage recorded by personal vehicles, extensive insulation of 85% of the current single-family housing stock within ten years, upgrades of current standards for new residential buildings and appliances, comprehensive improvements in commercial and residential lighting, and realization of cost-effective industrial conservation opportunities identified in a recent U.S. Department of Energy survey.

None of our estimates require the development of any new technologies, and all draw on empirical evidence about the performance of efficiency improvements in the field. The breakdown is as follows:

Table A

PERCENTAGE REDUCTIONS IN 1987 U.S. CARBON DIOXIDE EMISSIONS
ATTAINABLE THROUGH SELECTED FEDERAL AND STATE ACTIONS
TO PROMOTE ENERGY EFFICIENCY BY THE YEARS 2000 AND 2005,
ASSUMING SUSTAINED ECONOMIC GROWTH

MEASURE	2000	2005
Auto/Lt Truck Fuel Economy Standards	3.9-4.9%	5.1-6.1%
Residential Building Shell Improvements	2.0-2.6%	3.2-3.8%
Appliance Efficiency Standards	2.0-3.0%	3.0-4.0%
Commercial Lighting Standards	1.8-2.4%	3.6-4.2%
Industrial Efficiency Gains	1.7-3.8%	3.8-6.8%
Residential Lighting Improvements	0.3-0.5%	0.3-0.5%
Renewed Mass Transit Support	0.2-0.4%	0.5-0.7%
Total	12-18%	20-26%

The conservation "resources" captured in these percentage points and tenths of percentage points are enormous, by comparison to unexploited options for increased energy production. Figures 1 and 2 (attached) depict calculations demonstrating that potential oil and gas savings from Table A's residential and transportation measures alone could deliver at least twice as much oil and oil substitutes as the Arctic National Wildlife Refuge plus all unleased undersea lands under federal control.²⁶ The oil production curve in Figure 2 is based on the U.S. Geological Survey's estimate of economically recoverable resources.

Our projections are illustrative only; all represent options that would be explored in S. 324's planning process. Again, the categories in Table A do not come close to exhausting the national inventory of untapped conservation opportunities.

Of course, while many advocates of a national least-cost plan expect that conservation will dominate its investment and regulatory agenda, others have very different expectations. Some still insist that nuclear power is poised for recovery, and the nation does not lack for enthusiasts about sun, wind and tides. The point is to suspend ideological certitude and to stage a fair competition in a public forum.

Another of the bill's many excellent features is its recognition that state regulatory systems must be restructured to create financial incentives for utility investment in least-cost resources, including efficiency improvements. The National Association of Regulatory Utility Commissioners, through its Conservation Committee, has determined that under traditional ratemaking systems "profit motive generally encourages utilities to invest in supply-side resources even when demand-side

²⁶These figures are taken from a recent NRDC study by Robert K. Watson, Fact Sheet on Oil and Conservation Resources (September 1988).

alternatives are clearly identified . . . as being the least-cost resource."²⁷ Reforms are needed "to make the least-cost plan a utility's most profitable resource plan";²⁸ rather than attempting prematurely to mandate a particular solution, S. 324 simply ensures that every state will address and resolve this crucial issue within two years (§ 311).

Finally, S. 324 would set in motion two major regulatory reforms. The recent Wirth/Heinz amendment to the bill responds to uncertainty about the Department of Transportation's authority to raise fuel economy standards for automobiles above 27.5 MPG; this amendment and parallel efforts like Congresswoman Schneider's H. R. 1078 would target the largest CO₂ reductions available from any single policy initiative, as illustrated above. Two other entries in Table A involve lighting efficiencies, which should benefit greatly from the mandate for standards governing incandescent and fluorescent lamps (§ 308).

Although in general the drafters of this bill have done their work extremely well, some technical corrections would improve it; a brief Appendix offers our suggestions. Among the most important are to bind all federal agencies, not just the Department of Energy, to the national least-cost energy plan; to provide funding dedicated specifically to the new least-cost initiative (including related work at state and regional levels); and to tighten the criteria applied to U.S. financial support for energy projects abroad.

C. Beyond S. 324

Some promising additional candidates for legislative and regulatory attention include new and replacement windows (which S. 324 proposes only to label (§309)), and showerheads and other

²⁷Statement of Position of the NARUC Energy Conservation Committee on Least-Cost Planning Profitability, July 26, 1988.

²⁸Id.

plumbing fixtures. In all of these sectors, opportunities abound for delivering equivalent or improved services at significantly lower levels of energy consumption. Yet such opportunities remain largely unrealized, as a consequence of the market barriers reviewed earlier.

Congress also should move promptly to deprive carbon dioxide of its status as our most dangerous totally unregulated pollutant. Whether legislators select emissions limits, fees, mitigation requirements or some combination, the point is to capture in the price of consumer goods the cost to society of pollutants that are byproducts of manufacture. Greenhouse gases must start paying their own way.

CONCLUSION

The challenge addressed in this hearing is among the most formidable that the world has ever faced. An effective response will require more than this legislation can deliver, but S. 324 should lay the foundation for a sound national and international consensus on an extensive array of solutions. We endorse the bill, and we hope to help ensure its success.

Appendix: Proposed Technical Amendments

Note: A pattern of mutual cross-fertilization has characterized S. 324 and H.R. 1078, the Global Warming Prevention Act of 1989. The references below are dominated by provisions of H.R. 1078 that can readily be adapted to S. 324, which is similar in structure and purpose.

1. Title I, subsection (d): all federal agencies, not just the Department of Energy, should implement the Action Plan "to the maximum extent practicable."
2. Title I: insert H.R. 1078's excellent supplementary provisions on public involvement, intervenor funding, and analysis of energy subsidies, waste recycling, tree-planting, and transportation policy options (§§ 101(e)-(j)). Another key addition is H.R. 1078's "Least-Cost Electric Utility Planning Initiative" (§ 208), including its authorization of \$10,000,000 annually for technical support to the planning function.
3. Title III: We support the generally higher authorization levels for efficiency programs set out in H.R. 1078, which draw on recommendations in the American Council for an Energy Efficient Economy's Energy Efficiency: A New Agenda (July 1988). We also commend to the drafters the Weatherization Research Program described in § 309 of H.R. 1078.
4. Title III, section 313: remove an inexplicable invitation to states and non-regulated utilities to adopt the so-called "no-losers test", which arbitrarily limits utilities' conservation investments and has recently been rejected emphatically by regulators in Idaho, Massachusetts and Wisconsin. Section 313 would create a glaring asymmetry in PURPA's treatment of

conservation and generation resources, with conservation objectives emerging as the clear loser.

5. Title V, section 503: the definition of "integrated energy plans" is weak; the section should simply cross-reference the least-cost planning definition of Title I.

6. Title VI: Borrow § 509 of H.R. 1078 ("Demonstration of Biomass-Gasified Steam Injected Gas Turbines"), and § 702 ("Federal Demonstration of Intercooled, Steam-Injected Gas Turbines for Generating Power"), for reasons that have been set out at length by Professor Robert Williams of Princeton.

7. Title VI, section 614: The "Advisory Committee on Renewable Energy and Energy Efficiency Technology" should include public representation in addition to regulatory and industry members.

8. Title XIII, section 1301: As indicated in our testimony on last year's version of this bill (September 20, 1988), statutory assurances are urgently needed for a stepwise annual increase to \$300 million for the bilateral forestry program. Also, the activities described in this section should encompass all recipients of U.S. development aid, not just "tropical countries."

9. Title XIII, sections 1304 & 1305: Again, tighter definitions of least cost energy planning are needed, incorporating the elements set out in Title I. Cf. § 904 of H.R. 1078.

Figure 1. Daily Energy Savings from Selected Conservation Resources

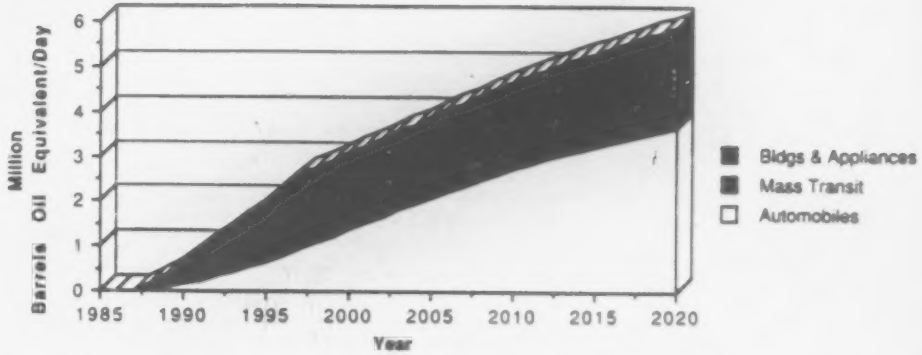
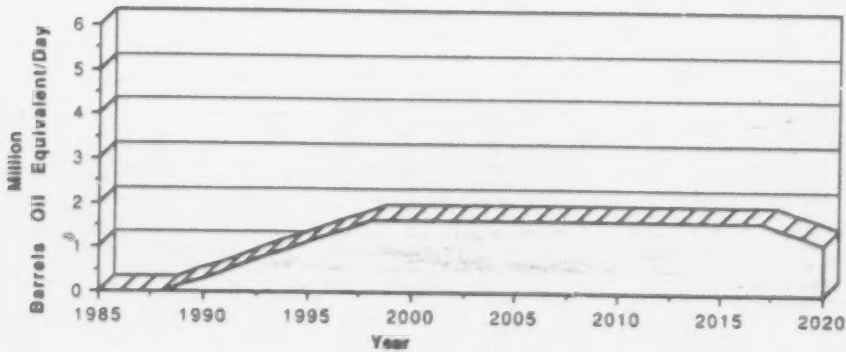


Figure 2. Hypothetical Daily Oil and Gas Production of Unleased OCS and Arctic National Wildlife Refuge Sources



Source:

Natural Resources Defense Council,
Oil and Conservation Resources
Fact Sheet (1988)

ENERGY

Conservation is a valuable resource

JIM JURA

Sooner or later, the Pacific Northwest will need new sources of electricity. Electricity needs are growing in our region, and sooner or later they will consume the surplus energy that the region now enjoys. Later is better, for all concerned.

That's why the Bonneville Power Administration is a natural leader in developing conservation resources. Well-chosen conservation measures are the region's best way to delay the day when expensive new sources of electricity will have to be acquired.

Today, 80 percent of BPA's power is hydroelectric. It comes from the dams on the Columbia River system. Although that source has limits, conservation measures offer us the potential of extending the benefits of one of the greatest non-polluting power sources in the world.

Alternatives to conservation exist and may be chosen to meet some of our electricity needs. But none is as attractive as conservation. We could build more dams or coal-fired plants. We could finish a pair of partially constructed, now mothballed, nuclear plants. But each of these options has its drawbacks — social, environmental or economic.

Significant new power may yet come from solar, wind and geothermal sources, but for now they are generally too expensive.

On our shelf of potential new resources, conservation is the first option we should reach for. It is socially and environmentally sound — and it is relatively simple. Adding insulation to the attic is easier than building and operating a complex power plant. And conservation can be brought on in smaller, more manageable increments, as needed to meet growth.

Conservation is also cheaper than

most other options. By paying for conservation, BPA can regain power for new loads at an average cost of about 2.4 cents per kilowatt-hour. It would cost 3.5 cents per kilowatt-hour to complete and operate one of the two mothballed nuclear plants in the Northwest. It would cost about 4 cents per kilowatt-hour for power from a new coal-fired plant.

The difference translates to a savings of hundreds of millions of dollars for Northwest ratepayers over the next 20 years. More and more, as the power surplus dwindles, Northwesters will — or should — look to conservation as the best way to keep their electricity bills in check.

When we talk about conservation as BPA, we're not talking about sacrifice or deprivation. Conservation means using electricity efficiently. Making every kilowatt count. Weatherizing homes. Designing offices, schools and factories to use less electricity. Showing irrigators how to pump the same amount of water using less juice.

Conservation is a resource, something we invest in. Since 1981, BPA has spent more than \$700 million acquiring conservation savings that will last 20 to 50 years. Many of the programs that accomplish these savings are carried out in consultation with the Northwest Power Planning Council and with the participation of Northwest utilities. By 1993 we expect to reach the \$1 billion mark in conservation programs.

We promote model conservation standards that have been incorporated into the building codes of 30 state and local governments. If all jurisdictions adopt these building codes, we expect them to save about 1,200 average megawatts annually by the year 2010. That's the equivalent of the output of about four coal-fired plants.

Conservation works. It worked to help turn around the "energy crisis" in the late 1970s, and it will work to extend our current energy surplus.

The difference today is that the public now sees no energy crisis. The perceived urgency — which boosted BPA and the Northwest into national and international leadership in conservation — has evaporated.

At BPA's most recent open meetings to set spending levels for 1990 and 1991, what we kept hearing from the public was to keep rates down. Cut costs now. Because we have made every effort to do that, our spending for conservation has leveled off. We have had to defer some conservation opportunities that make economic sense for the long run. We'd like to be doing more.

There remains much to be done. An estimated 450 more megawatts could be saved annually by the year 2010 if new federal efficiency standards were adopted for refrigerators and freezers. Under development are new fluorescent bulbs that consume 60 percent less electricity and last 10 times longer than the ones we buy today. Researchers report higher-efficiency motors that perform as well as older models but use 40 percent less electricity.

Another energy crunch is coming, sooner or later. We don't know exactly when. One clear lesson the Northwest learned over the past 15 years is to avoid overreacting to energy forecasts. But we have to be ready. And conservation is one of our best defenses.

There are a few other low-cost options. We are talking with the Canadians to better coordinate water storage in the Columbia. Cogeneration — using the steam that is a by-product of industry to generate electricity — looks promising. Seasonal exchanges of power with other regions can help. But conservation is the best, lowest-cost energy resource at our disposal today.

Jim Jura is administrator of the Bonneville Power Administration.

Vancouver Columbian
Sunday, February 19, 1989

Conservation must be chief source

It's a quirk of human nature that it often takes a crisis to make us act on something our intellect told us was coming all along.

A plane crash will bring closer scrutiny of airline baggage. Teen-age highway deaths bring calls for stricter sales of alcohol. The Arab oil embargo created what we called the "conservation ethic."

But that was 10 years ago, and the conservation ethic has work dangerously thin. Let's hope a near-crisis, mercifully not quite a real crisis, can have the same effect for change.

Recently, the Pacific Northwest was blasted by an Arctic cold front that came close to paralyzing all or parts of the region. In short, we faced record frigid temperatures with a fuel tank that was virtually empty.

To meet peak electricity demands during the crunch, the Northwest had to fire up an expensive coal-fired plant that hadn't been used in four years. The Bonneville Power Administration had to curtail energy supplies to the aluminum industry and the Northwest utility system turned to California to purchase power.

Ironically, WPPSS nuclear project 2 was out of commission for part of the extreme cold front, and part of the DC transmission line, which carries power between the Northwest and California, was blown down.

Had just one more of the Northwest's power plants been out of commission, we could have had a tragic situation. At the very least, power curtailments have severe repercussions for our recovering economy. At the worst, we simply could not survive massive outages to the residential community without tragic consequences, not in that kind of cold.

The cold spell dramatically underlines, and I cannot overstate this, the critical need for energy conservation. I'm not talking about the kind of conservation where we turn down thermostats and put on sweaters. I'm talking about the efficient production of energy where we maintain the same amenity levels. In fact, energy-efficient homes are more comfort-

Tom
Trulove

An expert's view

able. We have the world's best conservation technology; it's been tested and demonstrated and it's the cheapest way to meet our energy needs.

In 1983, the Northwest Power Planning Council developed model conservation standards for new buildings. These standards set energy efficiency levels that are both attainable and cost effective. Electrically heated houses built to the standards use half the energy consumed by comparable homes and they are at their most efficient during the very coldest weather.

Tacoma was the first city to adopt the standards. Seattle, Spokane and 18 other Washington municipalities have followed suit. But even with this program, only 11 percent of the Northwest's electrical housing has been built to these standards.

Legislation is pending before the Washington Legislature that would require the state's building code to meet the standards already well in effect in a number of Washington cities.

The council, whose job it is to do electrical energy planning for the Northwest, estimates that if all the Northwest's potential conservation were acquired over the next 20 years, it would amount to 2,600 megawatts saved. That's the equivalent of the power produced by six coal plants.

The council treats conservation as a resource for electricity. If you can save 100 megawatts, it's the equivalent of a plant that generates 100 megawatts. On average,

conservation costs less than half what it would cost to produce electricity through coal.

We've already benefited from some of the savings. During the last 10 years, Northwest conservation programs have saved an amount of energy that would have cost \$1.3 billion more to produce from coal plants.

What's more, conservation is environmentally clean. For energy planners, and ultimately ratepayers, there are other bonuses. Conservation minimizes the risk in energy planning because it can be developed in small increments and brought on line quickly when it's needed. A coal or nuclear plant can take 10 or more years to build and requires a huge capital investment. If it turns out the power is not needed when the plant is built,

as happened with the WPPSS nuclear projects, ratepayers end up paying for power they don't need.

Conservation, on the other hand, matches demand and supply. Each new house that's built adds to the demands placed on the power system. But each new house has the capacity for conservation measures. If we had built energy-efficient homes 10 years ago, we wouldn't be firing up a hugely expensive coal plant today to meet peak energy needs; we wouldn't be buying power from California; and we wouldn't be depressing our economic production by cutting energy supplies to aluminum and other industries.

It's time we began thinking long term. We've had a near crisis. We didn't escape unscathed. It cost us economically. Let's not wait until the next cold front.

Today we have a small electricity surplus when we're not facing a cold front. It's vanishing quickly and unless we do something now, the surplus will be gone within the next decade. We've run out of time.

A statewide energy code meeting the council's standards is the cheapest, safest, least-risk and most environmentally benign solution to a rapidly approaching energy crisis.

Tom Trulove is chairman of the Northwest Power Planning Council.

Senator WIRTH. Thank you all very much. I appreciate your very careful and detailed testimony.

It seems to me that there is a temptation for all of us in this business to talk to ourselves. I have heard each of you in the past. I'm not sure, Dr. Williams, that I have heard you testify, but the others and all the familiar faces of the usual suspects in the room here as well.

I am troubled by this at a time when prices are down and we are probably seeing the greatest glut of oil ever in the international market's enormous discoveries in the Middle East where there are continuing concerns about economic development and the traditional correlations between energy use and economic development, which you all understand have to be broken. But there is a common perception on that front. There is no crisis like the Arab oil embargo of the mid-1970s, and there is probably sort of a vague awareness of global warming, although that awareness is growing.

I state all of that by saying how do we get beyond the debate within the crowd of the usual people. And maybe one of the ways that we do that is we hold hearings and you try to do things dramatically and get on television and so on. But there is also the megaphone or the microphone of the White House and the presidency. There is no single variable that can enter the equation more rapidly and more effectively than the President of the United States who said—and Senator McClure and I were there at the swearing in of Admiral Watkins—it was very important for us to have a national energy policy, that the Energy Department was here to stay, I mean, very important words.

Let me ask you all briefly. If you were recommending to the President of the United States three things that he should say and do right now, what would you recommend that he do? Again, the purpose is to break outside of this circle and to raise this issue in public attention where there are inexpensive energy prices, economic concerns, concerns about the budget reflected here this morning. What are the three things that you would suggest to the President that he say or do? Dr. Gibbons.

Dr. GIBBONS. Since I am the oldest at the table, I guess I better go first.

This has to be a little bit off of the head, Senator, but I believe it is important for us all to recognize that the President is perhaps the most important teacher that exists in America. And that affords an extraordinary opportunity as well as responsibility for the President to articulate these national issues that transcend our individual interests. I think someone said that the ultimate in democratic process mutual coercion. And mutual coercion is a result of a lesson that can only be given from the White House.

The second thing, it seems to me, the White House might want to think about is to take into account—and as I am sure Admiral Watkins is doing today—a reexamination of the fundamental strategies and priorities that have underlain our past energy policies and an updating of those, taking into account these new issues, particularly the global warming issues. How does that affect our traditional orientations within the Department of Energy toward energy research, for example?

A third I think is that the Federal Government itself is a major consumer, and that energy decisions made within the context of the Federal Government's own operations is another part of that teaching process, that demonstration process, that leadership process, and that the Federal Government itself throughout its agencies could well reexamine its practices in the light of these new external costs of energy that are now being recognized and let it be reflected in their policies and purchase decisions.

Senator WIRTH. Dr. Blair.

Dr. BLAIR. Those are certainly three I would have picked, since Jack is my boss.

Dr. GIBBONS. That's the advantage of going first. [Laughter.]

Dr. BLAIR. But I might add several as well.

I think paying the premium on our insurance policy—for years we have asserted that new technology will be very important in the decades to come and paying that premium is going to be fairly important not just on the research and development phase, but on the demonstration phase over the next decade. And that demonstration phase needs to be done carefully because we have had some very bad experiences in the past.

Another point perhaps is because of this environment of low energy prices coupling energy policy to other dimensions of social and economic policy, those of us in the energy field sort of have thought for a long time of energy as a very, kind of almost independent discipline. And it is important I think to make sure that we can capitalize on other social and economic policies that are moving in the economy right now.

Senator WIRTH. Dr. Williams.

Dr. WILLIAMS. I would like to answer your question by making two suggestions instead of three, but I would like to subdivide one of them into three components.

First I think that foremost important is for the President to take the initiative in the global community and indicate that the United States is willing to take a leadership role in coping with this global warming problem.

And I think that first of all we have to get our own house in order. We should establish some kind of a national target with regard to CO₂, where we are going over the next couple of decades, and we should do things like—I would say one of the highest energy efficiency priorities should be the improved fuel economy in my opinion.

And the third thing in putting our domestic house in order is considerably more emphasis on research, development and demonstration on both the supply side and the demand side with regard to low CO₂ emitting strategies.

The second component besides putting our own house in order I think is the United States should launch a major effort vis-a-vis the developing countries and say that we are willing to work with developing countries to help them pursue CO₂ mitigating strategies that are consistent with their overall development goals. And we have to make that commitment, and this means bringing in considerations of a wide range of issues, including dealing with the debt problem.

Mr. CAVANAGH. I agree with much of that, Mr. Chairman, but I think the most important single thing the President could do on behalf of what I think many of us regard as the most promising single strategy here—and that's energy efficiency—is to just change the symbolism. What Americans learned from the last two Presidents was that energy conservation and energy efficiency was all about freezing in the dark and sweltering in the summer.

I think that probably the most useful single thing the President could do would be to direct the White House staff to replace all of the incandescent light bulbs in that structure with Art Rosenfeld's screw-in fluorescents that deliver the same lighting services for one-fourth the electricity and to do some other demonstrations on that order to make Americans understand that what we are talking about here is finding ways to get more work out of less energy and not ways to suffer.

There are two specific regulatory things that haven't been mentioned, that ought to be done, and that I know you, Senator Wirth, are particularly concerned about. The Department of Energy has before it right now appliance efficiency standards for refrigerators, freezers and televisions, the very core of every American's quality of life. Those standards at the moment, Mr. Chairman, decline even to consider two-thirds of the potentially cost-effective energy efficiency improvements that are available.

I know you and many of the rest of us here in this room have urged the Department of Energy to reconsider, and that is a critical thing that can happen in the immediate future, as is a change in approach by the Federal Energy Regulatory Commission to ensure that when utilities go out and seek bids for new sources of power supply, that they let energy conservation entrepreneurs compete on equal terms with power plant sponsors for ratepayer dollars. If we could get those two things and a change in the symbolism, we would be well on the way toward some real progress in this area.

Senator WIRTH. Well, I thank you all very much. I raised that point because it is enormously important that we get the public over a threshold. We have seen the increased attention up here, but we are going to have to have to see—and I think we are beginning to see signs of that with Secretary Baker's statement, the EPA report that was out today, the statements made by Secretary Watkins, all of which are very welcome. This has to come in a much more coordinated and much more urgent fashion if we are going to be able to succeed up here in passing the enabling legislation, and that can only happen if people of the country are catalyzed behind such an effort and supportive of it.

And I appreciate your thoughts. I think many of us here are going to continue to push on that front to make sure that both ends of Pennsylvania Avenue are operating with the kind of urgency that I think this issue deserves.

Senator McClure.

Senator McCLURE. May I yield?

Senator WIRTH. Senator Burns.

Senator BURNS. Thank you very much, Mr. Chairman.

First of all, I want to congratulate Mr. Cavanagh. I know you have done a lot of work with Montana Power up there, and I think you just did a tremendous job up there.

I have a couple of questions.

I am interested in your light bulb, by the way, after paying the heating bills in Montana. And I will say before this committee that the people in Montana this winter are not particularly interested in the warming issue that is going around. [Laughter.]

It is a hard sell up there that it is really happening.

I am wondering—and I will address this to Mr. Cavanagh—if you would agree that in the process of developing an energy policy, that the main drawback in that development, that we have not maybe done as good a job in assessing our weaknesses and our strengths, and probably setting some realistic goals and a time limit and the means to attain those goals—it always seems to me whenever we get on policy-setting, that we tend to forget to reassess ourselves and to set some realistic goals. And with that, as we do that, sometimes I have the feeling that in doing that, the government is an obstacle rather than a help.

So, I would just like to hear you comment on that because I have the feeling that we have not done a good job in that area. Then I have another question for Dr. Williams.

Mr. CAVANAGH. Thank you, Senator Burns.

I think the goal-setting activity that you describe is perhaps best captured by reminding ourselves how we do things in the northwest where for electrical power planning purposes, we take a look at what we think our future energy needs are going to be, and then we ask the question, well, what alternatives are available for meeting those needs and what are the least costly alternatives. As the former chairman of your Northwest Power Planning Council put it, the goal ought to be to buy as little as we need and buy it as cheaply as possible.

It is remarkable that at the Federal level in the Department of Energy, there has been no attempt rigorously to lay side by side energy efficiency options and energy production options and try to develop a policy that selects the best buys first. And this bill sets finally in motion a planning process along the lines that we have already used in the northwest.

Now, in terms of the potentially obstructive and destructive role of government, it is important to emphasize that I am not suggesting, nor do I think anyone in this room supports, the nationalization of the energy industry. What I am suggesting is that the Federal Government is already extensively involved in numerous respects in the regulation of energy services and in the expenditure of money that has some impact on the delivery of energy services, and that it makes sense to see if we are doing that in a way again that is pursuing the best buys first.

It also seems to me that the proper role of government, Senator Burns, that we could also agree upon is identifying environmental costs and problems that aren't captured in the marketplace and looking for a way to deal with them and identifying obstacles to the free functioning of a marketplace that are preventing the best buys from emerging first.

The reason, for example, I would submit to you, Senator Burns, that you don't have Arthur Rosenfeld's light bulbs all through your own home right now and that many of your constituents don't have them has more to do with obstacles in the marketplace than it has to do with any single feature of national energy policy. And it is identifying and removing those obstacles that I would hope this committee is in part about.

I will just close by saying that it may well be that no one of us in this room right now could agree on a comprehensive energy plan if we had to lay it out at this moment, but that I think that this bill creates a public process that allows for the possibility of our coming together. And that may be its most important single contribution.

Senator BURNS. And I would direct a question—this is just something I ran across the other day. And, you know, we run across a lot of things. With all that junk that comes into my office, out of there something good should come but very seldom does.

Are you aware of a fuel cell now that has been developed using nuclear waste?

Dr. WILLIAMS. No, I am not.

Senator BURNS. I have one for you. So, we will visit later on.

Mr. Chairman, I yield. Thank you very much. I appreciate that.

Senator WIRTH. Thank you, Senator Burns.

Senator Rockefeller.

Senator ROCKEFELLER. Thank you, Mr. Chairman.

I would address this I guess to Dr. Gibbons or any of you, but don't please all feel obliged to answer. [Laughter.]

As I read S. 324, the heart of the bill is something called the least-cost national energy plan, and that is we have agreed reduces energy use by a specified amount per unit of GNP by the year 2005. And next I see that the plan appears to give priority in reaching these targets to what is called cost-effective energy resources.

This leads me to consider cost-effective. What goes into the word "cost-effective"? And the answer seems to be that cost-effective takes into account distribution, that it takes into account quantifiable environmental and national security goals and something called benefits.

What I do not see in the consideration of the word "cost-effective" is anything about employment impacts. And I don't quite know how it is that in working on a national energy policy or, in fact, doing something which would be, as Mr. Cavanagh alluded to when he used the word "industrial" planning which is not what we are talking about here, but we are talking about here—but we are talking about major reorganization—I think we can say that—within our economy.

Sometimes employment factors come at you without planning. And I will give you an example. When I became governor of West Virginia in 1977, there were 66,000 coal miners working. And they were producing about 110 million tons of coal. Now there are about 20,000, maximum 21,000, coal miners working in West Virginia, and they are producing 130 plus million tons of coal. Now, there is a reason for that, and it is called long wall mining. That is technology. It is a private sector decision.

I applaud the efficiency. I was stunned, hurt and wounded personally as the governor who is a human being about the cost in terms of employment so that that was a decision made by the private sector.

The same thing happened in steel over the last eight years in this country. We have laid off 365,000 steel workers, and there are now only about 165,000 working. Also private sector decision making, rationalizing of the steel industry, all within the free market system.

But when you make public policy, is there not also a responsibility to look at the impact of what it is we do on jobs and people? And I would be interested in what some of you might have to say about that.

Dr. GIBBONS. Senator Rockefeller, I will try a brief response. I think you have triggered a very important issue, and that is when you do try to lay out this notion of least-cost paths, you implicitly dodge a very tough question and that is, what do you mean by cost. And cost occurs in many ways. Certainly employment is one of them, and in the public sector, that has to be more explicitly part of the calculus than in perhaps the private sector.

The dilemma of increased labor productivity, such as in West Virginia, was I think epitomized by a statement Harry Bridges made when he settled on a longshoremen's strike that from that point onward, they would lose jobs only by attrition rather than layoff. And he said by the turn of the century, there is only going to be one worker left on the docks, but he is going to be the best paid worker in America that exists. Unfortunately, most of that pay will go to unemployment compensation for his brethren.

So, you do have to take labor into account and you can do that to some extent by use of what is called input-output analysis to track the impacts of given decisions across the labor spectrum, jobs created here or jobs removed there.

I would say in general that the notion of improving the efficiency with which we use energy implies that jobs are more likely to be created in the place where energy is used, that is, where people are, in cities, and that the jobs are broadly spread across the economy and are probably more labor-intensive than jobs in producing energy. Now, it is a broad statement that ought to be backed up by careful input-output and other type analyses, but I believe I can make the claim that that is likely to be the case.

Senator ROCKEFELLER. And understanding that, do you think it is reasonable that within the creation of public policy, as in S. 324, that that matter of employment should be specifically addressed when measuring cost benefit?

Dr. GIBBONS. Indeed, I think it should be taken into account.

Mr. CAVANAGH. Senator, if I could just note, there is an excellent of the type that Mr. Gibbons has just referred to commissioned by the Bonneville Power Administration as part of its own least-cost planning and resource acquisition activity. And I can certainly get that for you if the BPA witnesses today don't have it with them.

I would also just note there is a lesson we might try to take in this matter from the Canadians. I agree that the impacts you have been describing are real and need to be considered. It is important, though, that when the Canadians talk about job impacts of energy

development, what they invariably end up meaning is the relatively small number of very visible jobs connected with very large scale energy projects sited in one place which attract a substantial work force for a brief period that everyone can take credit for. And they overlook completely the more diffuse, diversified, extensive employment impacts that Dr. Gibbons referred to that are associated with the job gains you get if you can reduce people's energy costs.

And I would just urge that it is important to look at both, not simply at the job impacts of the single, large-scale, highly visible projects, but at the overall picture of the entire economy analyzed in the way that Dr. Gibbons proposed to do it and in the way that the Bonneville study, in fact, does do it, trading off energy conservation investment against investment in large-scale generating facilities.

Senator ROCKEFELLER. Let me follow on that for a moment. Dr. Gibbons, you were talking about a net job gain factor. And that is interesting because that is kind of a public planning phrase. The Japanese do that very well. In other words, if they see that steel is going to be going down, which it is not just now in Japan, but it was under 100 million tons and going down further because Taiwan and Korea were taking that market away from them. It is up now because of their construction.

But, nevertheless, Kawasaki Steel and others, when they see that within an industry or within a company or within an area, that there is going to be job loss, they don't say, well, let's figure out the net gain/net loss factor on a national scale.

The Japanese don't say that. They say—Kawasaki Steel, for example, they get into the book business. They get into the software floppy disk business. In other words, they look ahead and they say if there is going to be job loss as a result of national policy—and, of course, there is a great deal of that in Japan—then that will be addressed within an area, within an industry, and indeed by their own corporate strategy within a company so that there is not this matter of net job gain/net job loss. One deals with employment factors, towns, communities, individuals, people.

So, I think your answer, Dr. Gibbons, was inadequate, and I would ask you to respond to what I have just said.

Dr. GIBBONS. Certainly my answer was incomplete, Senator, and you are quite correct in pointing out that if you would simply stop at the so-called economic numbers of people, you have missed the issue of regional impacts. And you have also missed the extraordinarily important question of training and maintaining a versatile work force, well educated, so that as job opportunities change, people can change the nature of their work. And this is extremely well-focused in Japan, far better off than perhaps we are, and in need of a great deal of additional attention here in the states.

Senator ROCKEFELLER. But do you think that that problem, as I addressed it, should be addressed, referred to, taken into account in this bill?

Dr. GIBBONS. Well, I am not about to say where the bill should stop or start. The bill obviously can't do everything, but the bill, it seems to me, needs to be sensitive to the overall impacts of legislation. And those overall impacts do include impacts on employment which means not only total numbers of jobs in the states, but

where the jobs appear and where the jobs disappear regionally and also in terms of what kinds of vocations.

And without an understanding of that, it seems to me it is going to be difficult for you members to decide whether or not you favor such legislation. So, such analysis I think should be called for in the exploration of this bill.

Senator ROCKEFELLER. Any other comments on this?

[No response.]

Senator ROCKEFELLER. Mr. Chairman, I have a couple more questions, if that is all right. Are we under a time limit here?

Senator WIRTH. We are always under a time limit, Senator Rockefeller.

Senator ROCKEFELLER. Good. So I can feel free to proceed then. [Laughter.]

Senator WIRTH. You're in the Senate now. [Laughter.]

Senator ROCKEFELLER. I guess my wrap-up comment and the last thing is that I fear what you in a sense referred to, Mr. Cavanagh, and that is the social planning factor of this because there are winners and there are losers when one makes public policy. And when one is dealing with losers, they tend to come in certain parts of the country and certain very specific parts of the country. And I don't think we can just cavalierly toss that off. I am not, at least, prepared to do that.

Let me press on another issue having to do with research funding. It strikes me that in this bill, the research funding is heavily tilted towards nuclear energy and towards natural gas and, in fact, I must say rather away from coal, \$500 million for nuclear, \$300 million for natural gas, \$45 million for coal. And I understand the response may come back and they say, well, there is a lot of money for clean coal technology. But this is a comprehensive approach to a problem and, therefore, it seems to me that a balance of research and a balance of looking at the possibilities of various sources of energy has to have integrity within the context of this bill itself, which then leads me to the thought that there are a lot of people who think that coal is a bad thing, and I think they are wrong.

I think that coal is going to be around a lot longer than natural gas is, that under the methanol bill that was passed by this Congress, it is the purpose—one of the purposes of that bill is to back oil out of the transportation sector of our country. That is, 100 billion gallons of gasoline are burned every year in this country, that trying to back out over a period of years oil which, in fact, on a CO₂ basis produces 10 percent more CO₂ than does coal, is significant. It is significant.

Now, I would just ask you if you think that there is a bias, and do you think that there is something in coal which makes all you very nervous. West Virginia I might say has more natural gas than any state east of the Mississippi. It is not easily obtainable but, nevertheless, it's a fact.

Mr. Cavanagh, I don't know whether the Natural Resources Defense Council supported the methanol bill last year, but the last witness at this hearing indicated, calling back from New York, that they did not because they said that the methanol bill was dangerous because of coal. That is interesting because natural gas is the

initial beneficiary of the methanol bill, and that supplies only about 20 percent of the CO₂ that we do in this country.

Coal is out there in the future. Natural gas has a life span of X numbers of years. We don't know how long that is going to be, but we do know that at some point, it is going to stop. In my opening comments to this committee, we were talking about is this bill looking far enough ahead. I mentioned does it look far enough ahead. Is the scope large enough on it? At some point coal comes into play by definition, or else everything is nuclear. It is either going to coal or it is going to be nuclear, or probably a combination of both.

And, therefore, the approach to coal in this bill strikes me as extremely important. My only clue here so far is that in research, it is highly underfunded relative to other sources within this bill. And I would appreciate comments that you might have about that, any of you.

Dr. WILLIAMS. I would like to make a comment or two on the coal issue.

I notice one thing within the bill. It says in the context of worrying about the CO₂ problem, the future of coal is going to depend on strategies for making much more efficient use of coal than we have been doing in the past. And that is very important.

I would like to make a comment about the character of the clean coal program at the present time in that regard and suggest that not nearly enough emphasis has been given to that. One of the most promising areas for making much more efficient use of coal in relation to existing steam electric power generation, which accounts for about 85 percent of all coal in this country, is the emphasis that needs to be given to these high efficiency gas turbines that can be married to coal.

Now, it turns out within the clean coal program, there is absolutely nothing going on today that exploits this country's enormous comparative advantage in gas turbine technology, and that relates to the aeroderivative turbine technology which has the potential of moving on a very fast track over the course of the next couple of decades with regard to efficiency improvements. Instead, the only demonstration project that we have under way under the clean coal program is one that is based on heavy-duty industrial turbine technology for which the United States has no comparative advantage whatsoever with relation to the rest of the world. And it also is going to be more difficult over time to improve the technology through incorporating these engine developments there.

Second, if we move in this direction for coal, it is also going to be important for biomass. It is also going to be important for urban refuse. The same technology you can use in all three of these applications with minor modifications.

Senator ROCKEFELLER. Mr. Cavanagh.

Mr. CAVANAGH. Senator, you have given me a lot to respond to, and I will try.

I think I want first to challenge your conclusion that it is either coal or nuclear or some combination of both, as you put it, as you look out to the future. I think Mr. Sklar on the next panel will have something to say about that.

Senator ROCKEFELLER. I left out solar and a lot of other things, and I totally agree with that.

Mr. CAVANAGH. Right.

I think the good news also is that we don't have to make premature commitments now to new, large-scale, very high cost technology. The good news is we have some time to weigh those choices and look at them.

And Senator McClure will recall that back when we started the northwest power planning process, everyone thought the question was going to be are we going to have to add a lot of coal or are we going to have to add a lot of nuclear. The answer turned out to be we don't have to add any of either. We have time to breathe. We have time to develop our efficiency alternatives and get a better sense of where we should be going.

Now, Senator, with regard to coal and the skepticism about coal, it has in this context one, single source which is rooted in the laws of physics, which is you get more carbon dioxide per unit of useful heat from that fuel than any other fossil fuel. That is going to be there, and we are going to have to deal with it.

The context in which I am urging us to deal with it is the planning framework of this bill which I hope adjusted to reflect the employment issues that you are discussing will allow us a forum to see how much we can do with coal in the context of the other resources, and allow the competitive process to go forward and recognize an obligation, if there are losers in the process, to deal with their needs, but also to recognize that, well, you're right. Public policy does have winners and losers and absence of public policy often has winners and losers too. And the problem we are discussing today may be the best illustration of that.

And just finally on the specific issue of methanol, let me be clear on what our concern is. We recognize that in the near term, the methanol feedstock would be natural gas, and in that context we agree with you that the CO₂ issue is less clearly framed. Our concern is that if the Nation becomes largely dependent on methanol as a major transportation fuel, the only feedstock potentially and plausibly available now to meet that need would be coal. And at that point, the CO₂ concerns become very real and have not, as far as we can see, been adequately addressed in the context of looking at tradeoffs on fuel.

We would rather see, Senator, more emphasis in terms of transportation on increasing the efficiency of automobiles where for the past four years, the administration has rolled back the national fuel efficiency standards. It has pending before it right now a proposal to do the same thing for a fifth consecutive year. And I hope we can all agree that there at least we ought to unite in hoping for a better signal from the new administration.

Senator ROCKEFELLER. I understand that. I also understand that that is a reason why research done on coal for the purpose of being able, for example, to convert it cleanly into methanol is so important. I would never favor the using of coal at the present condition of the research in terms of methanol. It would be an unwise public policy. There is something in me which says that over a period of 20 years, it would be almost inconceivable that this country's either private sector or public research sector could not come up

with a clean way of making methanol from coal. I simply want to make that point.

And I want to make another point. I am not one of those who comes from Appalachia and who says that because there is a lot of coal in my state, that we don't have an environmental problem. I think there is an acid rain problem. I think it has to be solved. I think there is a global warming problem. I agreed not at all with Malcolm Wallop's description of it. I think these are serious problems. As the governor, I could see our own pH content and the effect of that in our streams in West Virginia. I am quite aware of all of that.

But I don't see coal as automatically the enemy that so many people do if one applies the research and the energy and the intensity and the money to the research so that coal can be made cleanly and can be burned cleanly. I can't believe American technology can't do that. In the middle of the Second World War, we didn't have synthetic rubber because we couldn't get it from the Philippines and other places. And presto, in six months we had synthetic rubber. That is a bit dramatic I agree. But I just can't believe we can't do this with coal.

We do not need to be afraid of coal. It is not evil. It is something that we will have for 400 years long after natural gas is gone. And if it can be done cleanly and if we can apply the research evenly and energetically to it, that it can be helpful.

The final point that I would make, Mr. Chairman, is simply a statistical one. I think I am right that 77 percent of the world's total CO₂ emissions are generated outside of the United States, and I think that I am correct that of 23 percent generated by the U.S., 45 percent comes from oil, 35 percent comes from coal, 20 percent comes from natural gas. And I think I am right that U.S. coal-fired power plants represent 6 percent of the world's total CO₂ and roughly 3 percent of total greenhouse emissions. It is obvious to me then that not only do we have to do work in this country ourselves, but others do too. I simply wished to make that point.

Senator WIRTH. Thank you very much, Senator Rockefeller.

I would just note that the legislation is not an enemy of coal by any means. If you look at the legislation, it has a major emphasis on efficiency, which is important for the coal industry like every place else. And I would just remind the Senator of the numbers in the legislation. By fiscal year 1991, the research being done on nuclear, efficiency and solar together are about \$550 million, and the research on clean coal will be about \$800 million.

So, I would just say that the Senator and his colleagues from coal country U.S.A. have done a wonderful job of advocating the interest of coal research. We are very aware of the fact that we are going to be burning coal for a long time.

Senator ROCKEFELLER. Well, Mr. Chairman, I fully recognize clean coal technology has a very strong present life in the context of this bill. I mean, there is no guarantee that goes on forever.

Senator WIRTH. Well, there is no guarantee that anything goes on forever.

Senator ROCKEFELLER. I understand, but within the context of this bill, I had to take note of the fact that coal was distinctly shortchanged in terms of energy research.

Senator WIRTH. I would just remind the Senator he has not read the legislation. And if you would look at the legislation and what is involved in the legislation, we understand absolutely that we are going to be burning coal for a long time to come, and that in burning the coal for a long time to come, that means that we ought to be then paying attention to efficiency in the burning of that coal and cleanliness in the burning of that coal.

And, again, the numbers are very, very clear. In 1991, \$550 million total would be spent on nuclear, solar and efficiency, and \$800 million would be spent on clean coal technology. Now, that in my opinion is not inadequate attention.

Anyway, we can come back and do that. A lot of people, I would remind the Senator, have questions, in fact, of values of balance that are in the legislation so far, and have suggested that your friendly, local sponsor of the legislation, me, has way overextended my bounds in my attempt to encourage the Senator and other members from coal states to join us in this important effort, which I hope you will eventually do after coming to understand the numbers in the legislation.

Senator ROCKEFELLER. The Chairman is very glib, but I must point out—

Senator WIRTH. Not very glib, I—

Senator ROCKEFELLER. I must point out again that you are correct when you are saying that 1991 through 1993, you talk about \$500 million for nuclear—and then you added on solar there—\$300 million for natural gas, and for coal there is in your bill \$45 million. Now, I recognize that clean coal technology, a lot of which does not have to do with CO₂ problems, but has quite another mission, is a major factor.

Senator WIRTH. Senator, would you just read the legislation and see that this is on top of what we are currently spending.

Senator ROCKEFELLER. From other programs.

Senator WIRTH. That's right, on top of what we are currently spending. You are going to be ending up with more than \$800 million being spent on clean coal. What would you like to see? Let us know.

I think there are important points here, and I just didn't want the record to go untended to suggest that that this is a piece of legislation that is destroying the coal industry and destroying an important work force in the country and so on. That is the furthest thing from the truth.

We can talk about this later. I don't want to extend this any further than necessary, but I think that some of the comments that the Senator might have been suggesting about what was in the legislation simply are not accurate, nor is the thrust of the legislation to be destroying the coal industry accurate. It is not what the legislation is doing. We can talk about that, and if there are ambiguities in the legislation or whatever that ought to be cleared up, we will be very happy to do so.

Senator ROCKEFELLER. I thank the Chair.

Senator WIRTH. Senator McClure?

Senator McCLURE. Thank you very much.

I think one of the difficulties I have in addressing this panel, let alone addressing the bill, is the complexity of the issues that are

involved. You scarcely know where to start which isn't to say we shouldn't start, perhaps to say we have a heightened reason to start. And I know that whatever questions I ask or comments that I make are going to leave vast areas untouched, and some people will immediately jump to conclusions that because I didn't touch them all, I'm not concerned about them all, which almost impels me to say nothing, but not quite.

I don't know exactly where, as a matter of public policy, we begin and leave off a central question that is of concern to me and that is where do you use incentives and where do you use coercion and they are both involved. You induce people to do things in their own interest, and sometimes you force them to do things that they didn't want to do because we believe it is in their interest. And public policy always struggles between those two.

I am reminded of one part of the Pacific Northwest Power Planning Council objectives of trying to get more fuel efficiency in homes, and we went into the energy efficiency standards. And I recognize there are two components to what is economically efficient. One is what economically efficient for the region, which may be different than what is economically efficient for the homeowner. The council eventually decided that it had to be economically efficient for the homeowner, and we would address that question without trying to make the homeowner pay something for efficiency for the region.

And then I sat down with a pencil and started looking at how you measure efficiency in economic terms. If it costs more for the homeowner to build a house than he saves in energy costs, it is not economically efficient for that homeowner. And then you enter the other side of that question. If, indeed, you can't quite get to that point of economic efficiency for the homeowner, do you then coerce the homeowner, or do you find some other way of either reducing costs or increasing the economic benefits to the homeowner?

And we tried a number of things like that. We certainly did in the aluminum industry, for example, reward the industry for finding energy efficiencies. We said that is a resource we are going to use and we are going to see that the people who mobilize the energy efficiency get the economic reward for that mobilization of energy efficiency. And that greatly changed the opportunity costs on installing more energy efficiency in the aluminum industry in the northwest.

Those are concerns that I have as we try to internalize costs, and I agree with that totally. We ought to, and we made a lot of progress in recent years in internalizing costs rather than leaving the external costs unaddressed. And yet, Senator Rockefeller, you addressed another one of those, the unemployment costs. Those are real costs. And while we look at internalizing environmental costs in the narrow sense of environmental costs, we maybe haven't done well enough in internalizing the other environmental costs in the broader sense of the definition of the environment, the environment of the people that you are concerned about, which I share.

So, I am not sure that this is the time or place we are going to come to definitive answers on the question between incentives and coercives, because they are both there and we should recognize they are both there. And we will not today in this panel or any

other panel fully address the question of all of the costs that we are going to internalize or those that we are going to leave external and how we address those costs if they are left external costs.

But there is one about which I am very much concerned, and that is it seems to me in this country we have more and more addressed these questions. And I don't think other countries have done a better job than we have. I reject that. I think we are doing better than most of the rest of the world in addressing these costs and these issues.

But we also have, either inadvertently or as a matter of public policy, exported our most environmentally damaging industries. We talk about what is happening down in Brazil, and I am glad that you went down there. And I suspect you shook them up. And there are some who have suggested you should have stayed there, and I don't share that. [Laughter.]

But you will look at their industries, and their industries have expanded dramatically in Brazil as a consequence of their competitive advantage because they pay no attention to the environmental consequences of their industry.

I have suggested that we find a way in which we at least equalize the incentive system so that we don't reward those people who pollute the most by lowering their costs of production but having free access to our markets. Why can't we find the environmental costs, however we wish to define that, merged into a unit of production that is marketed in this country and impose an environmental tariff at our border that at least equalizes the competitive position in our marketplace? We don't have to penalize them perhaps, but we ought to remove the reward. And right now there is a reward for them and other countries to be less concerned about environmental effects.

I agree with the statement that has been made, and I certainly agree with the Chairman that the—I love to hear Democrats quoting Teddy Roosevelt, a great Republican President, but the presidency is a bully pulpit and it is an opportunity for this President or any other President to further national and international goals, to speak about them. And I think we do need to be speaking towards the activities of other countries. But there are some very concrete measures that we can take other than just jawboning what they may do.

I think we may even get Canada to put some scrubbers on some of their plants in Canada. They were very anxious to have us do something about acid rain, while they did nothing. I think maybe a little bit of jawboning by our President and some Members of Congress have told them to put their money where their mouth is. If they really want to do something about it, share in meeting the solution of the problem.

And we are going to be challenged greatly on this global warming question. We can't solve that by ourselves. If we try to solve it by ourselves, we only exacerbate what I already see in terms of competitiveness worldwide because economics is involved whether it is involved in our country or in international trade.

So, I believe we have to address it on an international basis. We have to recognize the competitive aspects of whatever policy we im-

posed domestically, just as we must recognize the economic choices made within our own country between competing fuels and uses.

Mr. Cavanagh, I can't help but make one final comment with respect to our experience in the northwest because you are entirely right that we consume less energy in the northwest than we did. And part of that is because we had an economic disaster. We paid a tremendous price for some of those gains. Or let me put it the other way. Some of those gains were the derivative of a tremendous price we were paying for other reasons.

As energy costs have reduced, so has the economic opportunity for conservation been reduced. As economic cost of oil reduced, and as natural gas has come down in price, some of the alternatives that we might have seen for other energy sources have been reduced as well. The future for solar energy was extremely bright at \$35 a barrel for oil and much less currently bright at current prices of oil.

So, what you gain on one side, you lose on another side. As you drive prices up—and that is something we could do, and it has been suggested. Let's find a way to drive the price of oil up and make other fuel—make other opportunities, conservation and fuels and alternatives better.

You also begin to dampen that other effect that you referred to, Dr. Gibbons, and that is as you lose some employment in one area, you gain it in another. And part of the reason you gain it in another is because of increased efficiency or reduced cost. If you drive costs up, you lose some of the benefits of what you gained by increased energy consumption. And I am not one who believes that energy consumption by itself is either good or bad. It is what it causes to happen or permits to happen.

I make these rather general comments not asking for any specific responses because if there is a danger in this legislation—and our ability to move legislation lies in the complexity of the subject in which everybody that can identify a special interest that is more important to them than some other says no because of the overriding importance of a single issue. That is a reality which I don't know how to confront.

I am reminded that we have more concern about CO₂ and the greenhouse effect today than we would otherwise have had because some in our society didn't want us to move forward on nuclear energy. We have fewer problems with the nuclear energy because of that decision perhaps, but we have a greater problem in global warming.

Almost every policy that we might choose has an alternative. Every plus has a minus. And it is up to us to try to sort those out and determine which ones are of greater value. I made a passing comment to the Synthetic Fuels Corporation. I happen to think that was a good effort on our part, and I am sorry we stopped it. It was an expensive effort. It looks more expensive because the price of oil went down. But I would remind people if we were looking at \$8 per mcf natural gas, the Great Plains plant is a winner. And we have learned something in technology in the Great Plains plant, even though it wasn't an economic winner because we didn't foresee oil prices going down instead of remaining or going higher. There are economic consequences to that as well.

I ramble on a little bit, Mr. Chairman. We were talking about how do we move this legislation and what portions of it can we move. And I hope we can move some. We desperately need to develop broad national policies that deal with the several goals that we have. But what I see is a kind of a negative balance rather than a positive balance that has stymied the Congress and the administration and our society for too long. I just hope we find answers to some of these several questions at least in some of the areas addressed by the bill so that we can move forward.

Thank you, Mr. Chairman.

Senator WIRTH. Thank you, Senator McClure.

I just wanted to add, Senator Rockefeller, that balance is what we are trying to find in the research effort and in the development effort. If we have not done that, related to the very important coal area, which is an important part of the economy of the state that I come from as well, we ought to look and make sure that we are working to finding it.

I would also note that the impacts which you so eloquently and correctly spoke of related to the impacts on coal communities and coal mining communities. And your state and your economy and the job base are enormously important. And other states also have deep concerns about what the impacts might be.

We hear from the Floridians, you know, if we are not able to slow down global warming, the Everglades and much of southern Florida disappears as does much of southern Louisiana and a lot of their energy industry, as does a lot of the ski industry in my state if there is global warming. You know, we have some significant impacts too. So, we all have to try to think this through and address this with a sense of urgency. And we need to have the help and support of you all and your industry as well in developing a balance and getting this passed. And I hope that if we have not done a good job of trying to work that out, I hope that we can get input from you and from your staff to do so because it is a very important area that you have been addressing this morning, and we thank you.

Senator ROCKEFELLER. I appreciate the Chairman's statement.

Senator WIRTH. Thank you all very much. Mr. Cavanagh, we appreciate also the remarks from you and NRDC in support of the legislation. That is an important endorsement just as 10 days ago I got a letter from the United States Chamber of Commerce saying that they with a few reservations supported the legislation as well. So, we are making progress overall. Thank you all very much. I appreciate your being here.

What we would like to do, if we can, is to move through the next panel before breaking, and the next panel includes Dr. Tom Bath, the Manager of Analysis and Evaluation for the Solar Energy Research Institute in Golden; Dr. Arthur Rosenfeld from the Center for Building Sciences at Lawrence Berkeley in Berkeley; Mr. Jim Wolf, the Executive Director of the Alliance to Save Energy in Washington; and Dr. Scott Sklar, the Executive Director of the Solar Energy Industry Association in Arlington.

Gentlemen, we thank you all very much for being here. And, again, pursuing the rules of the committee, we will include your statements in full in the record and would ask that you summarize

those in whatever way you think would be most helpful and most useful.

Perhaps, Dr. Bath, we might start with you. Thank you very much for coming and please proceed.

STATEMENT OF DR. THOMAS D. BATH, MANAGER, ANALYSIS AND EVALUATION OFFICE, SOLAR ENERGY RESEARCH INSTITUTE

Dr. BATH. Thank you, Mr. Chairman. I will try to be brief because I know time is limited.

What I want to try to do today is to present a preliminary analysis that we at SERI have performed which we think may add a little bit of light to this issue, although maybe that is presumptive on our part. Certainly there are others larger and more generously endowed with resources than we that are doing analyses of policy and possibilities in this field. A few are the Office of Technology Assessment is coming forth weighing in with the report. The EPA has already issued a report on impacts and its mitigation study has made the New York Times this morning which shows that that is about to emerge as well. The Department of Energy is producing reports on this issue as mandated by Congress and we at SERI are helping to support that activity. And, of course, the Academy of Sciences is also formulating views.

What we have done is something that may be a little bit different. It is very limited because we had to rely on the work of others in formulating this view, but what we tried to do is ask ourselves, well, what might one do if you determined that you were to put a constraint on policy that all your decisions had to be economically neutral.

And the reason for pursuing that constraint is, in essence, that there is a tension between needs for competitiveness in the developed nations. There are needs for development in the less developed nations and other priorities that they have besides the rather ephemeral concerns about global warming, at least from their perspective.

And so, we said to ourselves, well, if you try to move in the direction of mitigation policies, but you didn't want to have to pay for it, what might occur. And so, in my written testimony is a set of scenarios that we have constructed to try to illuminate that issue.

It starts with a base case which is prepared by the Department of Energy's Office of Technology Policy which assumes a 2.7 percent annual economic real growth for the United States of America and reasonably continuing the trend of energy intensity per unit GNP which has existed over the past 15 years. This study suggests that CO₂ emissions, carbon emissions, would rise roughly 40 percent—38 percent. In that same study, renewable energy increases from 6 quads to 12 quads. And as I said, conservation is very significant.

Earlier witnesses indicated that there has been in the last couple of years a departure from energy intensity trends over the past 15 years that coincides in the price break in world oil prices. I think that is a matter of considerable concern as we look at this issue. It is not clear that there is a cause and effect relationship, but clearly there are perceptions about future energy prices today that are

very different than those perceptions were 5 or 10 years ago. And those perceptions tend to reduce the enthusiasm of investors for energy efficiency and conservation type investments.

Therefore, what we did was extend in our first case, which we compare with the base case, the current trend over the last two years on out to 2010. Well, this is what I guess should be called the worst case. It suggests that CO₂ emissions would go up over 60 percent. In that same scenario, renewable contribution drops from roughly 13 percent of the economy down to—or the energy mix, down to about 8.6 percent.

The next thing we did as another comparative study is do what everybody thinks ought to be done here, which is look at conservation and energy efficiency. So, we went to the Department of Energy's energy conservation multi-year plan which segregates between technologically achievable conservation technologies and economically achievable ones. And we said, well, let's deploy all the economically achievable ones or economically viable ones that the conservation multi-year plan says ought to weigh in here. And in doing that we, indeed, got substantial improvement in energy efficiency and reduced overall from the base case energy consumption by 2010 by about 16 quads. So, this was the most substantial single improvement in overall reduction in CO₂ emissions.

What that did, however, was take us to a place where instead of going up by 40 percent on carbon dioxide emissions, they went up by about 10 percent, actually 11 specifically. And in the same context, renewable energy's percentage of the energy mix increased to 14 percent.

Now, in order for something like that to actually occur, leadership is involved. We have seen over and over again that people tend not to internalize long-term views in investing in conservation technologies. They need some sort of stimulus, and whether it is rhetoric or whatever it is—let's just call it leadership for the time being—I submit that without aggressive leadership, these technologies would not be deployed to the extent that they should be to achieve this goal.

Well, I would then argue further that you might as well extend that same kind of leadership in the context of this issue to renewable energy and, in fact, also to natural gas since there was a substantial amount of natural gas backed out in this energy efficiency case. So, that is our next case, our scenario two, in which we found that by extending government leadership to this broader set of options, we were able to essentially hold CO₂ emissions flat, increase renewable energy to 19 percent of the energy mix, all without relying on any additional technologies. This is deploying conventional technologies already in existence, hydro, geothermal, biomass combustion, MSW, energy recovery, et cetera. I think this is an interesting conclusion.

And the next thing we did beyond that was to say, well, could we go any farther with renewable energy because that is our major interest here. And what we explored was opportunities for both reforestation and the deployment of Canadian hydropower. We feel that it is very reasonable to assume that by 2010, you can displace one and a half quads of coal with Canadian hydropower. Of course, you

have to import energy, and that is a negative. And everybody recognizes that.

Similarly we can offset about 3 quads of coal-derived CO₂ emissions with very reasonable reforestation and afforestation policies. The bottom line is a CO₂ reduction of 10 percent.

So, there's a set of cases for your review, and we would be pleased to answer questions on them.

The implications are I guess, first and foremost, renewable energy is a major component of this response. The second is we can't get there from here under the constraint of economic neutrality using present and projected alternate technologies.

So, we have really three options. We can bear costs to respond to try to get to the goal that you have identified in the bill. We can accelerate displacement by more aggressive policies going beyond leadership, whatever that is. Or we could develop other cost-effective alternatives.

I don't want to identify a favorite son among that list of three. I just want to lay them out like a cold fish and move on to say that the last part of my testimony speaks to what I see as the outstanding R&D opportunities that are available in an intensified program of renewable energy R&D.

I have looked at a lot of R&D over my career. I was at EPA in the days of Russell Train, and we had some oversight over that R&D program. And there were a lot of opportunities for a payout there. I have never seen anything like this. I think the opportunities are really unusual.

I think, in addition, there are other benefits, increased markets, increased jobs, increased national competitiveness, energy security and global political stability that might derive from the availability of energy through indigenous resources in nations across the globe.

In addition, if we can drive these technologies to cost competitiveness in today's depressed market environment, I think it is worthwhile to point out that in the region of the globe between 30 degrees north and south of the equator, these technologies will even be more competitive. The solar resource is more intense, and that is probably where we need the energy more than anywhere else.

So, finally, I guess I see a need for leadership to gain support for what seems to me to be a prudent course of action.

Thank you, sir.

[The prepared statement of Dr. Bath follows:]

Testimony of Dr. Thomas D. Bath

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Before the
United States Senate
Committee on Energy and Natural Resources

March 14, 1989

 ABSTRACT

This testimony addresses domestic responses to concerns about potential global climate change; in particular, the use of energy and its effect on the buildup of greenhouse gases; actions we might take to reduce energy-related carbon dioxide emissions, and the significant role renewable energy can play in this context. Specifically, the testimony suggests that:

- o The atmospheric buildup of greenhouse gases and the consequent threat of global warming is a valid concern and, absent remedial actions, will become increasingly difficult to deal with.
- o "Business as usual" energy policies, that is, allowing our energy consumption to rise while relying heavily on established technologies, will exacerbate the situation.
- o There is no single "answer" to abating global warming -- instead a series of actions will be required. For instance:
 - Slowing the build-up of carbon dioxide in the atmosphere by --
 - increasing the efficiency of energy use,
 - greatly increasing the use of non-CO₂ emitting energy sources, such as renewable energy resources, and
 - reversing trends toward global deforestation and undertaking programs of reforestation
 - Eliminate the use of chlorofluorocarbons.
 - Working to reduce other greenhouse gases.
- o Nationally, the government can provide strong leadership in support of these actions by developing sound policies that promote energy conservation and that solidly support R&D on alternative energy technologies.
- o Although national efforts are the necessary first steps, they are not sufficient. Global warming is an issue that requires international collaboration:
 - The U.S. and other developed nations should take the lead in developing alternative, yet benign, energy technologies and options.
 - These alternative energy technologies should be available without economic penalty to developing nations.
 - These technologies need to be made available before many of these countries become increasingly dependent upon their indigenous coal resources.
 - Action should be taken soon, including the development of international agreements and cooperation.
- o One integral element in our response should be to accelerate and expand our national R&D programs on conservation and renewable energy.

The domestic payoffs from those steps go beyond abating greenhouse gas emissions and increasing our energy sufficiency. By developing alternative technologies we also create jobs, open large domestic and international markets, increase our competitiveness, help our balance of payments, and engender our own political stability. But we are enmeshed in serious competition with nations like Japan and Germany who, at this point, are spending more on such R&D than we are. If we properly develop the renewable energy technologies, we may play a prominent role in these markets.

INTRODUCTION

I want to thank the Senate Committee on Energy and Natural Resources for inviting me to testify regarding the relation of renewable energy to the "National Energy Policy Act of 1989." My name is Dr. Thomas D. Bath, and I am manager of the Analysis and Evaluation Office at the Solar Energy Research Institute. Our office evaluates competitive energy market factors as they relate to the adoption of renewable energy technologies. Therefore, we are very interested in the environmental consequences of energy technologies, particularly their contributions to global warming. In response to this concern, we have performed a preliminary analysis of U.S. energy consumption patterns and their implications for global warming which is presented below. This analysis shows that renewable energy is an essential and substantial component of any strategy to mitigate the increase in world-wide emissions of carbon dioxide, the principal greenhouse gas.

THE CONTEXT OF GLOBAL WARMING

The time to move is now

There is a growing world-wide scientific consensus that potential global warming caused by greenhouse gases is a significant and increasing concern. This realization has grown beyond the scientific community. Global warming is emerging as a major public concern, and thus has become an important issue to our political leaders as well.

This hearing and those held last year by Senator Wirth are cases in point. Legislative proposals are being offered to address this important issue. These bills agree that the time for considered action on this issue is now; that sufficient evidence is in; and that further delay will only exacerbate the situation and make it ultimately more intransigent. It is time to move beyond data gathering (although it should continue) and toward the consideration of appropriate responses.

Nor is concern limited to Congress. The Bush Administration has also called for action. Secretary of State Baker stressed the importance of action on the matter to the Intergovernmental Panel on Climate Change (IPCC). Secretary of Energy Watkins, in his confirmation hearing before the Senate, stressed the importance of continuing pursuit of efficient technologies and alternate energy sources in this context.

Global warming is an international issue

The global warming issue is not confined to the United States. Leaders from many nations are beginning to emphasize the seriousness of the issue and the magnitude of the effort that will be required in response. It is recognized that global warming would not only affect the climate and natural environment of all nations, but would also more generally impact the relative economic well-being of nations. Thus, prudence dictates consideration of appropriate responses.

The economically developed nations need to lead the attempt to mitigate greenhouse gas emissions for two major reasons. First, we have more to lose. Global climatic change will affect vested economic interests and threaten to erode the value of long-term assets, which are much greater in the developed nations. Beyond this, the more structured economies of these developed nations will find it difficult to adapt to rapid and substantial change. Also, such change could be deleterious to national security and to the international political stability upon which we all depend for our prosperity.

Second, the developed nations possess the capability to effect the changes necessary to mitigate global warming. They have the scientific, technical, and economic resources to develop and implement alternative technologies.

We cannot, however, expect the developing countries to take the lead on this issue, or even to follow our lead, unless we can provide appropriate technologies at competitive prices. The top priority of the developing countries is to grow economically to meet the increasing needs of their people. They will use whatever energy resources are available that will best help them achieve their development goals whether it be coal, oil, or alternatives. To these nations, the realities of providing for economic means are far more tangible than the possible ramifications of global warming. Consequently, the developed nations must be prepared to bring to these countries benign technologies that will help meet their energy needs without excessive reliance on fossil energy.

However, the United States also has economic constraints. We should not damage our economic competitiveness in the search for response options. We should develop alternatives that will be cost effective in application. At the same time, successful development of economic alternative energy technologies could open up large new international markets for us and help ease our balance of payments deficit.

All of this implies that whatever course of action we take, we are well advised to use economic neutrality as a starting point in our thinking. The alternate energy technologies that we develop should not economically penalize those who adopt them. This is especially true of the developing nations, for they are constrained in their ability to raise capital and deploy energy systems. It is also true of applications in industrial societies, because the more cost-effective these systems are, the more readily they will enter the infrastructure without market intervention, and the sooner they can help mitigate the buildup of greenhouse gases.

Responding to global warming concerns

Several different gases contribute to the atmospheric greenhouse effect: chlorofluorocarbons (CFCs), carbon dioxide, nitrous oxide, methane, and others resulting from the operation of modern industrial society. Technology will provide the cornerstone of any strategies to reduce the emissions of these gases. We must also rely on foresight and good judgment in evaluating the risks and benefits of technologically-derived responses.

There are several options open to us, each of which can help alleviate the continued buildup of greenhouse gases. Of these, let me isolate what are perhaps the six most important actions.

First and foremost, there is the elimination of the manufacture and use of CFCs, which may be responsible for as much as 15% of the global warming trend. The international community has already recognized the importance of eliminating CFCs and has agreed to several accords in this direction; for example, the well-publicized Montreal protocol. Agreement on CFC elimination is driven largely by concern over the deterioration of the ozone layer. This decision is also important for addressing global warming. Eliminating CFCs is a priority that should not be restrained by the requirement of economic neutrality.

Second, we should seek means to reduce the increased release of other gases, especially carbon dioxide and nitrous oxide. This will require a change in how we use energy. A key element in this will be increased conservation and the use of more energy efficient technologies. This is one of the best strategies we can follow, since conservation can be inexpensive and very effective. Consider what has happened since the first "oil shock" in 1973. Most of the developed world has substantially decreased its ratio of energy use to GNP while continuing to progress economically.

The ratio in the United States, for example, decreased by over 26% from 1973 to 1986 while the U.S. economy grew by more than 35%, in real terms. Moreover, the U.S. ratio can be reduced even more if we continue to make our vehicles, appliances, buildings, and industries more energy efficient. Such energy efficiency options not only reduce greenhouse gas emissions; they enhance our competitiveness and support continued economic growth. For instance, using more energy efficient technologies available to us today in designing, lighting, heating, and cooling our buildings could save as much as 9 quads of energy annually. This is energy equivalent to over 4 million barrels of oil per day or 11% of current U.S. annual energy consumption.

Third, we must depend less on fossil fuels and turn increasingly to alternative energy supply, technologies that do not emit greenhouse gases to the atmosphere. Foremost amongst these are the renewable energy technologies, which can offer us energy in all the forms we require (heat, light, electricity, and liquid and gaseous fuels) and yet will not add to the increase of greenhouse gases. Also, a new generation of passively safe fission reactors could provide an important alternative for electrical generation if, at the same time, we can resolve issues such as nuclear waste disposal.

The fourth important action is substitution among presently used fuels. In the near term, one alternative is to substitute natural gas for coal and oil where and when feasible. Natural gas releases only about one-half the amount of carbon dioxide per Btu as coal and three-fourths that of oil. In the long run, fuels derived from renewable energy resources can be substituted for coal and oil. Affecting significant change in our patterns of energy consumption, as the second, third, and fourth options entail, will be an extremely difficult task that would take many years to accomplish. Our present energy consuming infrastructure will change slowly, and new technologies take time to develop and implement.

Fifth, we should explore land use and agricultural practices for cost-effective response options. We could, for example, use non-utilized or marginal land to plant trees to extract carbon dioxide from the atmosphere. We could also use fertile land that is currently set aside under federal agricultural programs for reforestation. Developing this land use pattern will provide feedstock potential for future biofuel technologies. Other options include selective breeding of livestock and genetically engineering crops so that less methane and nitrous oxide are generated.

The final leg is sustained government leadership.

THE SERI PRELIMINARY ANALYSIS ON ENERGY USE PATTERNS AND THE RELEASE OF CARBON DIOXIDE

A preliminary analysis has been performed by the Solar Energy Research Institute to illustrate the important role that renewable energy sources can play in a national mitigation strategy to reduce CO₂ emissions.

Five different scenarios of U.S. energy use in the year 2010 are described below. These descriptions include the probable fuel mix of energy consumption and the consequent increase or decrease in carbon emissions as compared to 1986 emissions. (1986 was used as the benchmark year for the base case scenario examined below.) A basic assumption common to each scenario was the constraint of economic neutrality; i.e., alternative energy system life cycle costs must be equivalent to conventional options. The sources used for the analysis were the published works of the DOE and others. Because this analysis relied on the work of others and is preliminary in many ways, it has certain limitations. For example, regional supply/demand matching was not performed nor were the price impacts of reduced demand (due to energy efficiency improvements) factored into the analysis. Also, because the emerging renewable technologies are seen as unlikely to make very large contributions in this time frame, the emphasis in analyzing renewable use changes in the various scenarios has been placed on the mature renewable technologies, such as hydropower and biomass combustion.

First, a base case was developed around which the other four scenarios are fashioned. The base case draws from the "Long-Range Energy Projections" developed in 1987 by the DOE Office of Technology Policy (OTP). The OTP "reference case" projects that the U.S. energy/GNP ratio will decline 27% (or 1.3%/yr. on average) from 1986 to 2010 while GNP nearly doubles. The OTP projects that the U.S. will consume 108.2 quads of energy by the year 2010. (A quad is a unit of energy equal to one quadrillion (10^{15}) Btus, which is equivalent to about one-half million barrels per day of petroleum consumption). Compared to the 1986 energy consumption of 76.6 quads, this is an increase of 31.6 quads, or 41%.

Use of all fossil fuels increases in the base case scenario. (See the appendix for detailed tabulations.) Most notable, coal consumption nearly doubles, due primarily to increased electric utility demand, while oil and gas consumption increases only slightly. The nuclear energy contribution increases 80% while that from renewable energy sources is projected to more than double, from 6.1 quads in 1986 to 12.7 quads in 2010. The base case scenario would increase carbon emissions by 38% over 1986 levels with this growth primarily due to the projected increase in coal consumption.

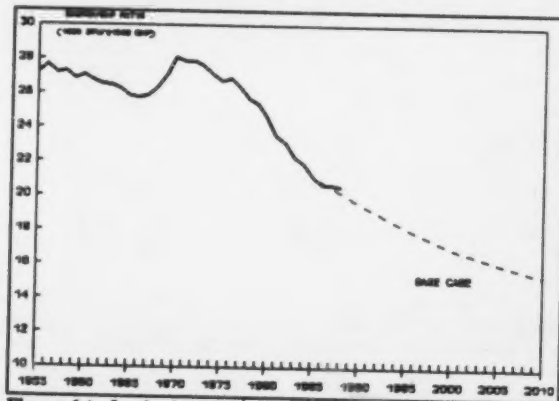


Figure 1A. In the base case scenario, the energy efficiency of the U.S. economy is projected to improve at an average rate of 1.3%/yr. to 2010.

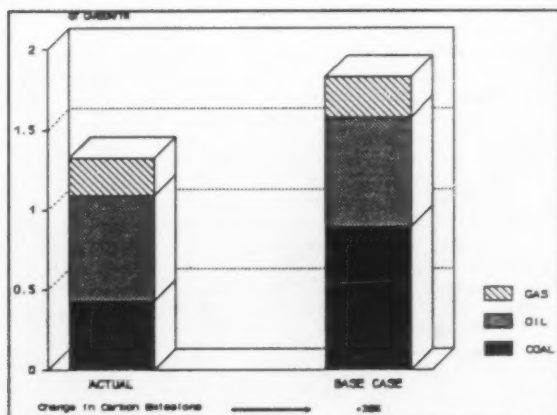


Figure 1B. The resulting energy consumption of 108.2 quads in 2010 implies a 38% increase in carbon emissions over 1986 levels.

While the base case projection scenario does not paint an optimistic picture for reducing our carbon emissions, CO₂ emissions in our Scenario 1 would be even greater. This scenario assumes that energy prices will remain low and that the very recent slowdown in U.S. energy efficiency improvement (1986-1988) continues to 2010. (Since the oil price break of 1986, we have seen a departure from the post-embargo trend in declining GNP energy intensity. I feel that the timing of this departure was no accident, and thus we examined a "low prices" case to explore its potential implications.) In this scenario, U.S. energy consumption would rise to 121.3 quads by the year 2010. This increase implies substantial escalations in the use of fossil fuels over the base case. Projected use increases by an additional 5.4 quads, oil by 6.6 quads, and gas by 3.3 quads. At the same time, because of the low prices of conventional energy, projected utilization of renewable energy technologies decreases by 2.2 quads. This scenario suggests greater carbon emissions, which we estimate would increase by 62% over the 1986 emissions level.

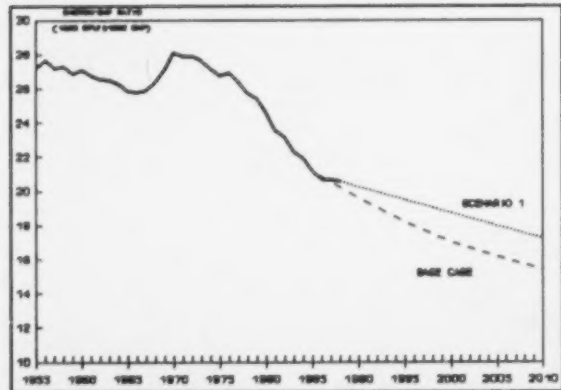


Figure 2A. Low energy prices may lead to a reduced rate of energy efficiency improvement in the future (Scenario 1).

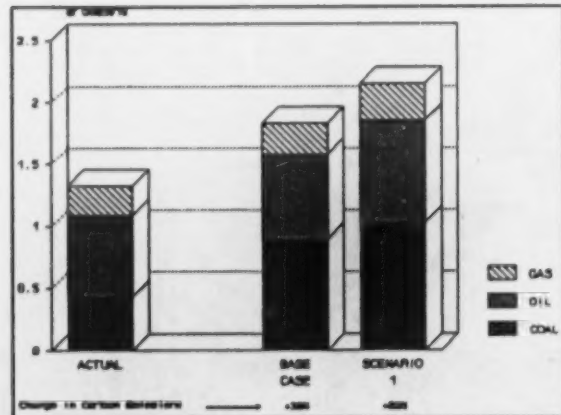


Figure 2B. The resulting increase in projected energy consumption would lead to a 62% increase in carbon emissions over 1986 levels.

Scenario 2 assumes that, over time, energy prices rise (as projected by the OTP study used to develop the base case scenario) and that all "cost effective" conservation technologies now available or projected to be available are adopted to a reasonable extent by energy consumers. (This scenario is based on information contained in the latest DOE Energy Conservation Program Multi-Year Plan, August 1988.) This results in an average energy efficiency improvement for the U.S. economy of 1.9%/yr., some 1.5 times greater than in the base case scenario but still somewhat below the actual 1973-1986 trend of improvement.

Even with substantial continued energy efficiency improvement, total energy consumption in Scenario 2 rises some 15 quads (or 20%) above the 1986 level. However, this scenario leads to "only" an 11% increase in carbon emissions over 1986 since a large amount of coal consumption (used for electricity generation) is "displaced" relative to the base case. Nevertheless, coal consumption still grows by over 40% compared to 1986. This scenario also projects a substantial (3 quad) reduction in natural gas consumption.

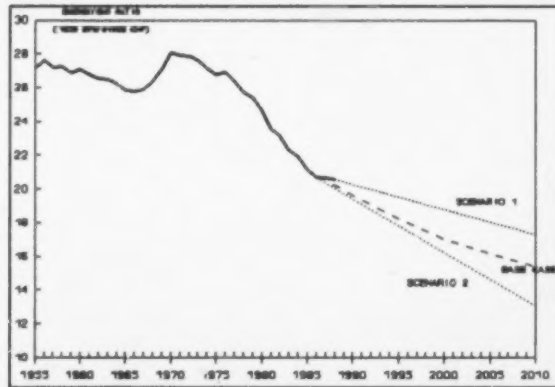


Figure 3A. A greater emphasis on conservation (Scenario 2) would lead to an acceleration of energy efficiency improvements (above the base case scenario)...

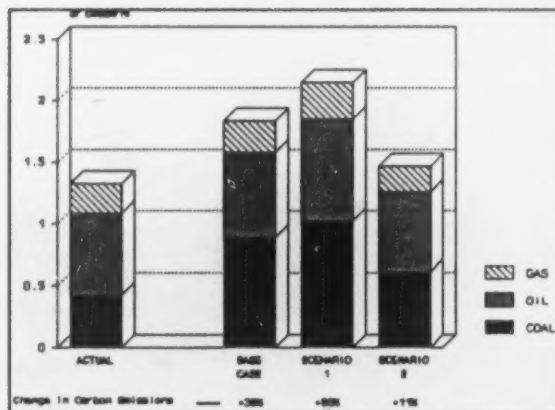


Figure 3B. ...and to a much smaller, though still positive, increase in carbon emissions above 1986 levels.

Scenario 2 provides an indication that conservation is a very important element in any strategy geared toward reducing fossil fuel CO₂ emissions but that conservation alone may not be enough to achieve actual reductions in CO₂ emissions.

Scenario 3 adds two additional carbon emission mitigation strategies to the conservation efforts portrayed in Scenario 2. These involve the substitution of 5 additional quads of renewable energy and 4 quads of natural gas (above the Scenario 2 projection) for coal in electricity generation. While the overall level of energy consumption remains at about 92 quads, carbon emissions are reduced by almost 12% from the Scenario 2 level, resulting in total energy-related carbon emissions some 2% below the 1986 level.

Scenario 3 shows that with a concerted effort, it may be possible to stem the rise in U.S. CO₂ emissions within the constraint of economic neutrality. However, further reductions in the level of carbon emissions will require additional effort.

Scenario 4 (the final scenario) incorporates additional renewable resource-related efforts that could be undertaken to further reduce carbon emissions. Canadian hydropower represents a vast untapped resource for emissions-free power generation. Estimates have placed the undeveloped Canadian Hydropower resource at about 3 quads. (U.S. DOE, NORTHERN LIGHTS: The Economic and Practical Potential of Imported Power from Canada, December, 1987) We assume here that one-half of this export potential could be realized to further displace coal consumption in power generation.

As mentioned previously, atmospheric CO₂ could be reduced by undertaking reforestation programs. Scenario 4 assumes that harvested federal lands are reforested, thereby fixing 30 million tons per year of atmospheric CO₂, and that one-half of the current inventory of crop set-aside lands are also planted with trees, thereby fixing an additional 45 million tons of carbon annually (William R. Moomaw, Director of Climate, Energy and Pollution Programs, World Resources Institute, in testimony before the U.S. Senate Committee on Agriculture, December 1, 1988). Both reforestation actions combined could offset an additional 2.9 quads of coal-related carbon emissions over a twenty year period.

As in Scenario 3, energy consumption in Scenario 4 remains at about 92 quads. However, the renewable resource options implemented result in a total additional displacement of 4.4 quads of coal-related carbon emissions. With these additional reductions, annual carbon emissions for the year 2010 in Scenario 4 are some 10% below the 1986 level.

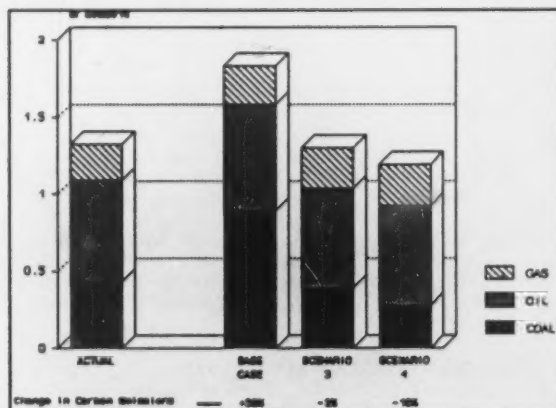


Figure 4. A greater emphasis on renewable energy resources and technologies can achieve actual carbon emission reductions from 1986 levels (Scenarios 3 and 4).

If nothing else, the analysis just described highlights the enormous obstacles inherent in achieving actual reductions in annual U.S. energy-related CO₂ emissions. It is clear that to achieve the 20% reductions called for in this legislation, we will need to employ other options.

From our analysis we can conclude that renewable energy and conservation technologies have the potential to significantly reduce carbon dioxide emissions. But, under the constraint of economic neutrality, this potential alone is not sufficient. Other actions are needed. One of those actions might be to go beyond the constraint of economic neutrality. Another might be to provide leadership; leadership that would provide strong policy incentives to displace conventional energy with cost-effective alternative energy technologies. Another action might be to develop other economically neutral options. This suggests continuing support for R&D on those alternative technologies that will help us reduce greenhouse gases. Developing and bringing these technologies to maturity could enable America and the world avert what may be emerging environmental catastrophes.

INTENSIFIED R&D ON RENEWABLE ENERGY WILL PAY DIVIDENDS

While other forms of energy technology, such as nuclear, efficient use of energy, and conservation technologies can make contributions to resolution of this issue, the renewable energy technologies present us with some of our most promising alternatives to the conventional technologies. Not only do they not contribute to carbon dioxide emissions, they also can provide us with energy in all the forms we need: electricity, light, heat, liquid and gaseous fuels. We are already beginning to see this promise start to flower.

Last year, the United States derived nearly 8% of its energy from renewable sources, a total of 6.5 quads of energy per year. And, as we have seen, assuming "business as usual," the OTP projects that by the year 2010 the renewable energy technologies will supply the United States with nearly twice as much energy as they do today--almost 13 quads, which would be 12% of America's total. The analysis above concludes that, with proper initiative, renewable energy could provide 21% of U.S. energy supply by 2010.

Although most of this energy is derived from the mature renewable technologies of hydroelectric power and the combustion of biomass and wastes, in the future an increasingly large percentage will be obtained from the emerging technologies of geothermal energy, wind energy, solar thermal, biofuels, photovoltaics, and others.

Before we can speak to opportunities to accelerate research on these, it is instinctive to review their progress in penetrating energy markets today.

Electric power from the energy of the earth's internal heat, geothermal energy, has grown from 12 MW of electricity in 1960 to nearly 2400 MW in 1987. With further advance, this technology's contribution can grow similarly over the coming decades.

Wind energy conversion, in which the mechanical energy of wind is transformed into electrical energy, has grown in like measure. Just a decade ago electricity produced from wind was a curiosity. Today, it is big business, with our 1500 MW of wind-electric capacity installed in California alone. In 1987, these wind machines generated more than 1.7 billion kilowatt-hours of energy.

Solar thermal technology, where the sun's rays are focused to produce large amounts of heat or electricity, also grew rapidly. Barely in existence a little more than a decade ago, this technology has progressed to where it now provides more than 200 MW of electrical capacity. Of these, 194 MW are installed in the Luz plant in the Southern California desert, where the plan is to increase the capacity to 575 MW in the next few years.

Biofuels is short-hand terminology for technologies for the production of energy (mostly liquid and gaseous fuels) from plants and waste. Through these technologies we can make ethanol, methanol, crude oil, and methane to heat our buildings, provide electricity, and liquid fuels for transportation. An example of the increasing importance of biofuels is the dramatic growth in ethanol production, which has risen to more than 800 million gallons a year. With further research and development, the price of ethanol from wood could decline to 60 cents a gallon within a decade. With these prices and with well-managed "farms," efficient use of municipal and agricultural wastes, some SERI scientists believe that the United States could produce between 130 billion and 260 billion gallons of ethanol per year. This is more than enough ethanol to run our entire transportation fleet. Of course, no one expects ethanol to penetrate the market soon on a scale that even approaches this magnitude.

Finally, photovoltaics (PV), the use of solid-state devices to generate electricity directly from sunlight, has also scored its share of remarkable successes. In the mid-1970s, PV was an expensive and exotic technology whose only application was to power satellites in space. Intense research and development has brought this incredible technology "down to earth" where it has found applications that range from running wrist watches, to providing electricity for homes, to powering entire communities. Today, the United States produces more than 10 MW of photovoltaic modules per year. Thousands of systems, ranging in size from milliwatts to megawatts, have been installed throughout the world.

Niche markets for domestic grid-connected PV are expected to evolve in the context of investment trade-offs between applications which take advantage of the system flexibility of PV (stand-alone and small system economics) versus extending or upgrading distribution and transmission capabilities. A number of major utilities have expressed intense interest in these trade-offs, recently. We believe that, by the turn of the century, photovoltaics should be adding more than 1 GW of capacity per year to the nation's power grid, and maybe as much to remote applications. By that time the cost of PV electricity will have dropped below 6 cents per kilowatt-hour, making it competitive with most current generating alternatives.

I think it is clear that the potential for emerging renewable energy technology to contribute to energy supplies and to stem the growth of carbon emission is great. But, under current trends, the amount of energy provided by these novel renewables will not be enough to reverse the increase in carbon emissions. We need to more quickly get the renewable technologies into the mainstream of the energy infrastructure.

To get the emerging and future renewable technologies into the American mainstream quickly and on a large scale, it is appropriate to consider intensifying and expanding R&D on emerging renewable energy technologies, as Bill S. 324 suggests. Because of fiscal constraints, we have had to pass up many promising avenues of research and focus only on those few that promise the highest probability of success. Consequently, these emerging technologies tend to enter the energy mainstream more slowly and tentatively than they otherwise might.

This situation is unfortunate, in my view, for without a doubt America's renewable resource is vast. Given today's technology, we can economically recover about 700 quads of the accessible renewable energy over the next 30 years. That's enough to economically supply America with 20% to 25% of her needs over the next few decades. With continued research and development, that percentage can grow. That is, as our technologies become more efficient and cost effective through discovery and development of new concepts, we will be able to recover progressively more of the vast solar resource. It is, therefore, clear that renewable energy is not resource-constrained; so why does it not represent a larger fraction of our energy mix today?

The answer to this rhetorical question lies in the functioning of the marketplace. In order to draw capital to the production and development of systems based on these emerging technologies, investors need to be able to convince themselves (through "due diligence" processes) that the technologies will perform predictably and reliably and that they will provide return on investment. This is where I think an intensified government/industry R&D program can

contribute--both through advancing the performance of the technologies and through enhancing the basis for investor confidence. Let me provide a few examples relevant to technology advancement:

Ethanol from biomass--In the last decade, researchers have reduced the cost of wood-derived ethanol from \$4.00 to \$1.35 per gallon. This has been done using biotechnology and genetic engineering. Current plans suggest a goal of 60 cents per gallon by 1995; however, there are reasonable prospects of attaining a goal as low as 45 cents per gallon, if a more intense, multi-path approach could be pursued. Ethanol at 45 cents per gallon is cost-equivalent to \$20 per barrel oil.

Electricity from wind--The current U.S. wind energy research budget supports basic research and the study of advanced components, but is insufficient to allow the design, development and testing of improved designs that can compete with European and Japanese systems expected to be in the market by 1995. A low cost, highly reliable advanced wind turbine would be competitive on the world market by generating electricity for 3-5 cents per kilowatt-hour at moderate (13-mph) wind sites. The technology base needed by U.S. industry to produce these advanced turbines can be developed by 1995, but only with increased federal/industry support.

Hydrogen technologies--Hydrogen provides the potential of an exceptionally clean fuel which will not contribute to global warming. At present, most hydrogen is made by reforming methane. When the electricity is made from fossil fuels or when methane is used, CO₂ is evolved. Renewables technologies for hydrogen production, such as photosplitting of water, provide the potential to totally circumvent CO₂ production. Current efforts in this area are limited. An increased effort would allow development of an integrated hydrogen program which could speed the deployment of this option.

Nor is simply intensifying research the only possibility. Activities to support investor confidence can also pay dividends and need consideration.

Although the domestic renewable industry has a scientific and technical advantage in most areas today, this has not been attained without substantial cost. For example, Arco Solar has invested over \$100 million over the past 7 or 8 years in some very promising PV options. This has been partially cost-shared with government (\$3 million). Their parent company has indicated an interest in liquidating this investment, and the primary bidders are foreign. Thus, the United States is at risk of losing an element of our technical advantage in the PV area. Expanding the government/industry efforts into this downstream arena (as is the case in many foreign nations) could reduce the frequency of such decisions.

Finally, we must also examine how we manage our energy technologies, both in domestic context and an international context. Domestically, we should revisit our R&D programs on such things as nuclear energy, fossil fuels, conservation, and renewables, and evaluate the directions in which they are proceeding and the relative merits of each *vis-a-vis* their ultimate ability to meet long-term energy objectives and their impact on the environment. Internationally, we should seek to maximize technological progress by cooperating with other developed nations by sharing information and by coordinating our R&D efforts in such a way as to minimize redundancy. Clearly, the renewable energy technologies should compete on their merits with opportunities in other areas for scarce R&D funds.

The payoffs for our efforts could be substantial, domestically and globally. First, it almost goes without saying that a successful effort to stem global warming will help the world avert major stresses, environmentally and politically. In addition, perfecting renewable systems and offering them and their technologies to developing nations will promote political stability in those nations and in the world, because nations could then meet their energy needs through use of indigenous energy resources, avoiding the fiscally draining and debilitating effect of importing their energy. Also, the renewable energy technologies can not only provide them with electricity, fuels,

chemicals, and heat, but they can do it on almost any scale, meeting the needs of a single household, of a small and remote village, or of city, allowing nations to pursue the development path most suited to their society.

To be most effective, however, we must introduce reliable and economic renewable technologies into the developing countries before they become too dependent upon coal and other fossil technologies. Because once that happens, the energy infrastructure can become resistant accommodation of new technologies, and our problems in mitigation of greenhouse emissions may become more difficult.

Thus, the domestic payoffs go beyond abating global warming and increasing our energy sufficiency. By developing the technologies, we also create jobs and large domestic and international markets, increase our competitiveness, help our balance of payments, and engender our own political stability. We are enmeshed in serious competition with nations like Japan and Germany who, at this point, are spending more on such R&D than we are. If we do not act to properly develop the renewable technologies, we may see other countries control the markets, both domestically and internationally, not only in the short-term but also in the long-term, when the markets will be huge and when the renewable technologies will begin to give the world substantial benefits.

APPENDIX

2010 ENERGY AND CARBON EMISSION SCENARIOS

ENERGY CONSUMPTION (IN QUADS)

	1986 (ACTUAL)	BASE CASE	SCENARIO #1	SCENARIO #2	SCENARIO #3	SCENARIO #4
COAL	17.3	36.0	41.4	24.6	15.7	14.2
OIL	32.2	33.5	40.1	31.6	31.6	31.6
GAS	16.4	17.6	20.9	14.5	18.5	18.5
NUCLEAR	4.5	8.1	8.1	8.1	8.1	8.1
RENEWABLES	6.1	12.7	10.5	12.7	17.6	17.6
IMPORTS	0.1	0.3	0.3	0.3	0.3	1.8
TOTAL	76.6	108.2	121.3	91.8	91.8	91.8

CO2 EMISSIONS (IN GIGATONS OF CARBON)

	1986 (ACTUAL)	BASE CASE	SCENARIO #1	SCENARIO #2	SCENARIO #3	SCENARIO #4
COAL	0.43	0.89	1.03	0.61	0.39	0.28
OIL	0.66	0.69	0.82	0.65	0.65	0.65
GAS	0.24	0.25	0.30	0.21	0.27	0.27
TOTAL*	1.32	1.83	2.15	1.47	1.30	1.19

*Totals may not add due to rounding

Senator WIRTH. Thank you very much, Dr. Bath.
Dr. Rosenfeld and the light bulb.

**STATEMENT OF DR. ARTHUR H. ROSENFELD, DIRECTOR, CENTER
FOR BUILDING SCIENCE, APPLIED SCIENCE DIVISION, LAW-
RENCE BERKELEY LABORATORY**

Dr. ROSENFELD. Of course. I am happy to be here.

I can't resist making a remark about the twin perils of the greenhouse effect and the White House effect. You asked what sorts of things the President could say, and I do want to echo that one of the things the President can say is completely consistent with what Bath has just said; namely, he could say that he is appalled to realize that the budget which he has just submitted for conservation R&D and for renewables R&D involves 50 percent cuts for this forthcoming year, which is going to be difficult to undo later, and call for a change in that.

And with respect to the light bulb, someone mailed me recently an announcement from a Tornton, New Jersey utility which I thought was pretty striking. This is the famous bulb which is four times as efficient as a—well, this is an 11 watt bulb which replaces a 50 watt incandescent. Ten million were sold last year, but they should saturate the market at more like 100 million. So, there is a way to go, and we should capitalize on that and push it along as fast as possible.

This Tornton, New Jersey utility now says to its customers, look. You can buy these in a hardware store for \$8, but you are being ripped by retail prices. We want to introduce them in a hurry. We can get them cheap. We will rent them to you for 20 cents a month. If you use them in your sockets for more than an hour a night, you will be ahead. I think that is a marvelous idea. That is the sort of leadership the President could call on the utilities of this country to do.

With a little action, we could get the 150 watts in each bulb above your head replaced with a 33 watt high efficiency bulb and save some of the country's \$8 billion electricity bill for the Federal Government. So, there are lots of little things.

It really doesn't matter what the President says, as long as he says something. It is the eight years of nothing that is particularly bothersome.

Senator WIRTH. I might say, Dr. Rosenfeld. We are working on this problem with the National Electrical Manufacturers Association.

Dr. ROSENFELD. Very good.

Senator WIRTH. They are coming in and helping us, and the architect of the Capitol has been supportive as well.

Dr. ROSENFELD. I am sure by the next time I come back, I will be basking under efficient lights.

I started off my testimony by talking about the enormous improvement in efficiency which we made from 1974 to 1985 while prices were high. And everyone has alluded to that, so I will say very little more on that except to take this opportunity now for four or five minutes to give you some examples concretely of why

that has worked so well and why it would be very profitable to get these products out into the marketplace.

And so, the first example which I want to take out of this box and wave around is a lamp bulb which, in fact, is not fluorescent. Although I am well known for advocating fluorescent bulbs, there are certain things they won't do like start when it is 20 below or turn on and off quickly for traffic lamps. This is a traffic lamp bulb made by Duro-test also in New Jersey. And I am going to pass it around.

First of all, if you look at the box, it is pretty impressive. It says, "65 watts replaces 100 watts." If you look at it, it has a slight sheen on it and that is because it has a few layers on the inside of tin oxide which is a reflector for heat, puts the heat back on the filament where it belongs, but lets the light out. That is all it takes to get a 50 percent improvement in this bulb.

So, this is a small greenhouse. It keeps the heat in. It lets the light out. That is what we want the world to do more of. And it introduces the idea of these reflective coatings which have been so successful.

I now want to wave around a few windows that do this sort of thing. Let me remind you then that a technology which we thought we would introduce in Berkeley starting about 1975 was to coat windows with a layer of reflector so that they would, in fact, let the light in from the sun, but keep the heat in the room.

And in order to get your attention on that, I want to remind you of a fact which I have said many times that the heat leaks through windows in the United States is pretty impressive. Every winter the total amount of heat that leaks out in residences plus commercial buildings in this country is only made up by one year's flow from the Alaska pipeline. So, when I think of Alaska, I think of the whole darned thing up there as doing nothing but supplying the energy which leaks out of badly designed windows.

So, we decided to try to do something about that, and found it was, in fact, very easy to coat glass with a heat mirror like the thing I have just showed you on the light bulb which will, in fact, leave the glass transparent, but keep the heat in your house. And this improves the efficiency of windows already. That is, such windows have already been adopted by Anderson Window, Pello Window and so on. They are called low-emissivity windows.

The surcost varies from nothing in Massachusetts where there is a price war on through maybe a six-year payback in California. But the paybacks are coming down very fast. And in a moment I am going to show you a picture on the easel of how effective that has been.

The new development on this is that there is now a company in California called Southwall in Palo Alto which has decided to use the same trick, but tune the windows so that not only does it keep low temperature, room temperature, heat into buildings, but it is recognized that office buildings have really more heat than they need, and it would be nice to keep out heat from the sun on a summer afternoon. And so, the next thing I want to send up is a sample from Southwall.

We are all used to seeing office buildings with pretty glass which is called solar control glass, and that keeps out the heat on a hot

afternoon but it keeps out the light. So, then you use daylighting. You have daylighting bills to pay. You have lighting bills to pay.

Here is a remarkable sample. It has two pieces in it. One is tinted green. It keeps out three-quarters of the light and is the conventional way to do the trick. The other is perfectly transparent, lets in all the light, will save for the United States \$1 billion to \$2 billion a year worth of electric lighting, but it is a heat mirror. So, there is a new piece of technology, a brand new industry, very competitive, could sell abroad, which is simply again the result of using these thin films carefully.

And finally, the latest one which I want to bring around is what we now call super window in Berkeley. A regular single-glazed window is called in units of resistance are one.

Double-glazing which has taken over in this country is two. I'm sorry. Low-emit windows are three and this is eight. It's payback time is still maybe four years, but it will come down.

Now, the impressive part about this window—and in my testimony I give you an example—is we have now tested this in Reno, Nevada in the winter. Reno is a climate which—Steve Wiel is here. It's pretty bad. It's a little worse than Chicago.

Facing north in Reno in a snowstorm, this collects more solar heat during the day than it leaks out at night. So, this window spells the end of need for space heating in residences in the United States more or less. And its payback time is already down to a few years. What it needs is demonstration.

So, there are several examples of where relatively modest R&D programs adding up to not more than \$10 million a year for—well, the total program in windows in Berkeley is \$1 million or \$2 million a year for five years—is already up to achieving sure savings of \$3 billion or \$4 billion a year.

Finally, I want to show you some pictures on the easel from a company in Concord, California which makes these coating plants. And I guess I will retreat from the mike and just talk very loud. And I will put this back a little further so that our press friends can perhaps see it too.

These are two pictures which I put here so I can point at them which are also in the appendix to my testimony. And they are entitled two ways to get \$1.3 billion worth of energy services.

One is a plant like this which over its lifetime will coat enough glass to make millions of windows which will go into houses and save heat, namely, natural gas. The other is simply to go drill for the oil off the California coast or perhaps in Alaska.

This plant generates enough—if I do the accounting this way, one day's production of this plant will make enough windows which, over their 20 or 30 year lifetime, will save 10,000 barrels a day of oil. And, incidentally, over the lifetime of the plant, that turns out to be 36 million barrels of oil worth about \$1 billion.

Here is another way to get 10,000 barrels a day of oil. So, these energy services are equivalent.

This is the pride of the Shell offshore fleet. It is a rig off the Santa Barbara coast. It produces 10,000 barrels a day. It costs \$330 million as opposed to \$8 million, an example I think of trying to use one's technology instead of one's brawn.

Apart from this huge cost, to give you some idea of the investment here, you are only seeing here basically not the top of the iceberg, but the top of an Eiffel Tower. This tower is, in fact, slightly higher than the Eiffel Tower. It is 700 feet. I think the Eiffel Tower is around 700 feet. It is so wide at the base, there was a difficulty in designing in so it would go under the bridges in the bay area before it could be towed out to sea. And it is nonrenewable. In 20 years this will drain the Santa Barbara coast.

The impressive part about this plant, which is renewable, is that Airco Solar Products which sells this plant has now sold, in fact, 35 of these plants. That will over their lifetime save more oil than exists off the California coast and the proposed oil under the Alaska National Wildlife Refuge, all of which can be reproduced by selling a plant which costs \$7 million.

So, the moral to the story is that this technology, started about 10 years ago, is still paying off marvelously. I repeat here is \$2 billion of electric light savings per year. Here is probably another \$5 billion worth of heat savings per year on the way, and these research projects have worked out simply magnificently.

The last things I want to wave around are the following. One of the things that we tried to do with windows in Lawrence Berkeley Lab was not using thin films, but was using a project called aerogel. This is a window which looks transparent, but in fact it is filled with an inch of material which is 5 percent glass, tiny, tiny particles that don't scatter light, and 95 percent air. It is not perfectly clear, so until last year, we were using it only in skylights and architectural glass walls.

Then the CFC fear hit, and the chemical companies announced that they were going to stop producing large quantities of CFCs. But the foam in refrigerators which keeps your refrigerator and your freezer cool is, in fact, blown with chlorinated fluorocarbons. And the manufacturers became quite scared that they wouldn't be able to meet the 1993 California standards.

We realized at LBL that this was a marvelous material for this. As packaged here, this is our 20 per inch. I remind you that the wall of your house, if it is a typical four-inch wall, is our 11, or if it is a six-inch wall is our 19. This is our 20 in a single inch. By making it opaque, because in a refrigerator it doesn't matter if it is opaque, we decided we can go to between our 30 and our 40 per inch. So, it looks like this is solution to the refrigerator people's problems.

Here it is already packed in a food packing industry vacuum which is all it needs to last 20 years we hope.

The interesting thing about this piece of technology development is that if this works out as well as we now think it will, manufacturers will be able to use this material in one-inch thicknesses instead of having to go two and a half inches to meet the California 1993 standards. That will allow for the same outside dimensions, a refrigerator to up, go through the same door, but go up in inside dimensions from 20 cubic feet to 22 cubic feet which is said to be worth \$100 retail, which will more than pay for the new insulation. So, there is a new export market, all of which comes out of research that started about 10 years ago.

I think that I have used my time up and I will hope that the rest of it can be read. Thank you very much, Senator Wirth.
[The prepared statement of Dr. Rosenfeld follows:]

**THE IMPORTANCE OF ENERGY EFFICIENCY
RESEARCH AND DEVELOPMENT
IN THE U.S. BUILDINGS SECTOR**

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Oversight Hearing on:
Senate Bill 324
National Energy Policy Act of 1989
Subcommittee on Energy and Natural Resources
J. Bennett Johnston, Chairman
United States Senate

March 14, 1989

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1. Introduction

Improving energy efficiency in buildings, industry, and transportation can cap world fossil fuel use, delay global warming for 20 to 40 years, and provide time necessary to develop safe reliable renewable energy supply options such as nuclear, solar, ocean, and wind power and biomass, all of which are expensive now but should be cheap in 20 to 40 years. From 1973 to 1986 energy conservation and improved efficiency have allowed a 35% growth in U.S. GNP with no increase in total energy use¹, and a slight decrease in fossil fuel (see Figure 1). Compared with efficiencies frozen at 1973 levels the U.S. has avoided \$150 billion per year in energy bills—\$100 billion due to improved energy efficiency, and \$50 billion due to structural change. U.S. energy conservation is currently saving about 14 million barrels of oil plus gas per day (about one-half the capacity of OPEC), and, compared to 1973 projections, is saving about 50% on its electricity bill—worth almost \$100 billion and equivalent to the annual output of 250 baseload power plants². Improved energy efficiency worldwide is currently saving about 28 million barrels of oil plus gas per day—one whole OPEC. This is the main reason oil prices are low, and they can continue to stay low as long as OPEC production is kept below 80% of capacity (see Figure 2).

The environmental benefits from improved energy efficiency are even more than 35% because we have avoided raising coal production. If the U.S. were still operating at 1973 efficiency levels we would have pumped 50% more carbon dioxide, sulfur dioxide, and nitrogen dioxide into the atmosphere during 1986. Reducing these pollutants has helped ease the problems of global warming and acid rain. But we can do much better. In fact my personal goal is to reduce total U.S. energy consumption per unit of GNP by 3.5% per year. This would permit 2.5% annual growth, and still cut U.S. energy use and fossil-fuel emissions by one-half over the next 70 years. The technology is already available for the first 10-20 years of this path—such as more energy-efficient lights, windows, appliances, motors, and cars—but we need economic incentives to turn the technical solutions into reality. In addition, if we are to reduce dependence on fossil fuels well into the next century we must invest now in energy-efficiency research and development (R&D).

2. Energy-Efficiency R&D

Most energy-efficiency R&D in the U.S. and elsewhere has been government supported—with the notable exception of the airline industry. Government-supported energy-efficiency R&D

¹About one-third of this savings is due to structural change in the U.S. economy (i.e. decreased production of primary metals, and increased foreign imports of automobiles, steel, etc.).

²Assumes a baseload power plant produces 5 billion kWh/year and the average retail price of electricity is 6.3¢/kWh.

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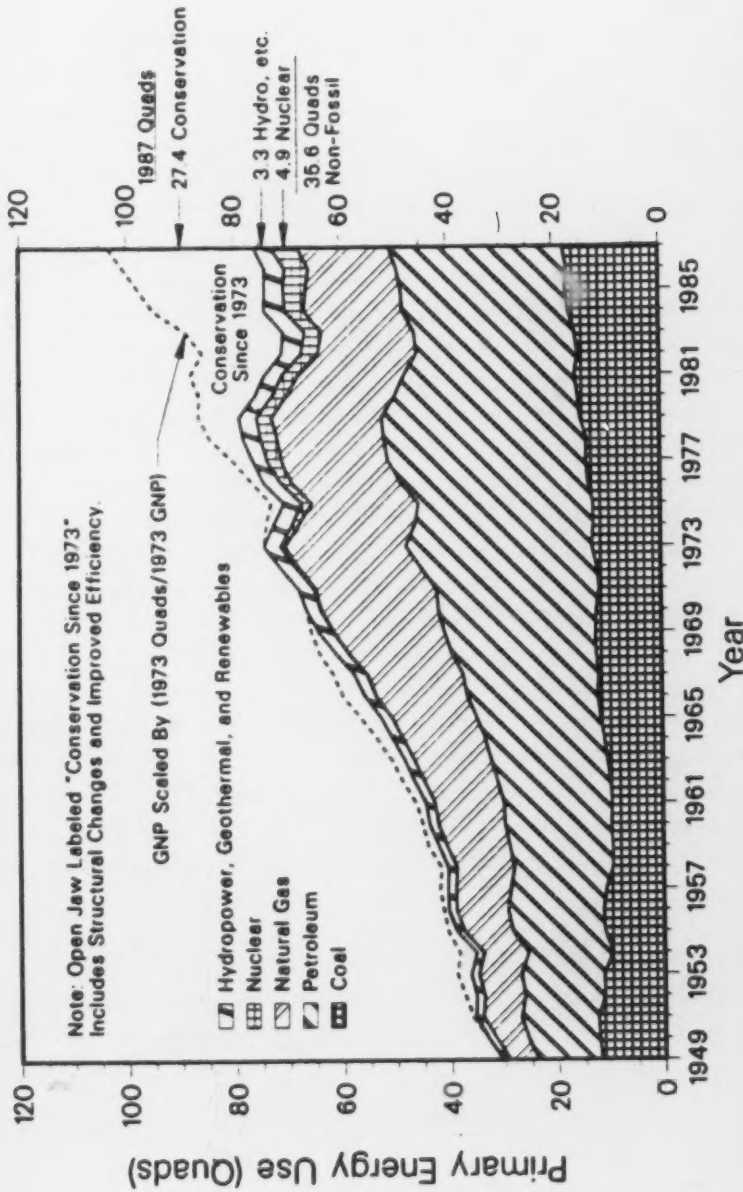


Figure 1. U.S. Primary Energy Use: Actual vs. Predicted by GNP (1949-1987). The figure shows energy consumption by source. The upper dashed line is GNP in 1982 dollars scaled to go through 74.3 quads (1 quad = 10^{15} BTU) in 1973, and illustrates how GNP and energy use were in a lock-step before 1973. Energy conservation and improved efficiency have made a significant contribution to the U.S. economy since 1973 and currently provide annual savings of more than 27 quads—worth \$150 billion. Adding the contribution from conservation to the other non-fossil sources gives 35.6 quads—equal to one-third of the energy we would have used if we were still operating at 1973 levels. Sources: US87, US88b, CEA88.

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OPEC Pricing Behavior (1975-1988)

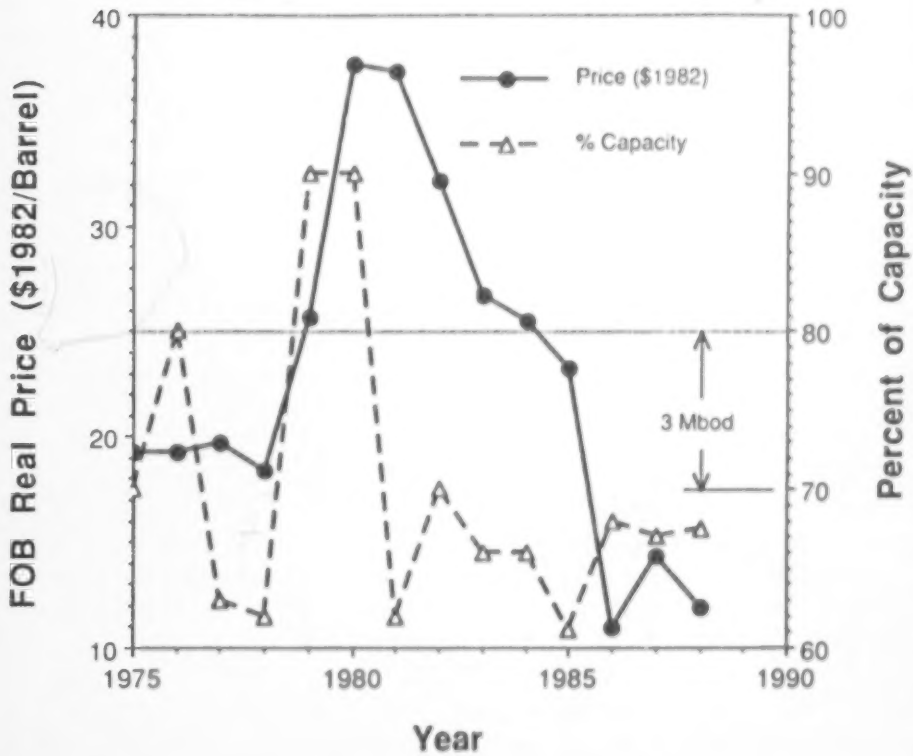


Figure 2. OPEC Pricing Behavior (1975-1988). The figure suggests that OPEC was able to maintain or increase prices only during those years when 80% or more of its capacity was in use. We currently have slightly more than a 3 million barrel of oil per day (Mbod) margin below the 80% capacity line where OPEC can once again regain control of world oil prices. Source: US86.

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has produced many successful technologies for transportation, industry, and buildings³. I will limit my discussion here to the buildings sector since this is my primary area of expertise.

Table 1 shows the dramatic savings from four energy-efficient technologies that were sponsored by the Department of Energy (DoE) Office of Buildings and Community Systems (BCS). These advanced technologies are currently saving American consumers over \$12 billion per year. Once these technologies reach saturation they will produce annual savings of over \$28 billion, obviating the need for 44 GW (44 baseload power plants)⁴. If we assume that all of the displaced power is coal-fired, the savings amount to over 130 million tons of carbon—almost 10% of current U.S. carbon emissions. These projected savings are based on commercially available products. More recent developments in fluorescent tube design, super-windows, and aerogel insulation for refrigerators could yield savings twice as great as what is given in **Table 1**. Other less obvious developments include building simulation computer models that are the basis of building energy standards which have halved the energy use of new buildings.

Buildings research includes generic technology developments shown in **Table 1** as well as systems R&D such as rediscovering the "oasis effect" produced by increasing vegetation and the use of lighter-colored surfaces in urban areas to reduce summer heat islands. A brief discussion of these follows:

• *Energy-efficient Lighting*

Figure 3 shows the evolution of electronic ballasts for fluorescent lamps and the new compact fluorescent lamps. The ballasts increased the efficiency of fluorescent lighting by about 30%, have a payback time of a year, and over their 10 year lifetime will save about \$50 of electricity and 500 pounds of coal. The compact fluorescent lamps have a simple payback of less than 1-year, and over their several-year life save about \$40 of electricity or about 400 pounds of coal. Dr. Sam Berman and his group of researchers at Lawrence Berkeley Laboratory (LBL) are currently working on new technologies that will further double the efficiency of electric lighting

• *Windows*

In the United States every year the combined heat leak from windows is equivalent to an average of 1.7 million barrels of oil per day—the twenty-year average of the output from the Alaska pipeline. Adding a "heat-mirror" or low-emissivity (low-e) coating to double-pane windows will save about one-half million barrels of oil per day—about one-third of an Alaska.

³A sector by sector analysis of energy efficiency potential for the U.S. is given in [B188] and a detailed analysis of the energy efficiency potential in the transportation sector is given by [US88a].

⁴The savings given in **Table 1** are based on direct replacement of the existing stock and neglect growth in each sector. The actual savings will be much greater since projected growth in the buildings industry is about 2.5% per year.

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Table 1. Selected Energy-efficient Technologies: Current Savings and Predicted Savings at Saturation [Ge87].

	Electronic ballasts	Compact Fluorescents (PL-9) ^a	Windows Low-E ^b	Refrigerators ^c 1987 California Title 10
• Life	35,000 hr	10,000 hr	30 yr	20 yr
• Cost Premium	\$12	~ 0	0-\$2.00/ft ²	\$100
• Lifetime Savings per unit				
\$	\$100	\$40	\$10/ft ²	\$1600
Energy	1000 kWh	400 kWh	1.5 M Btu/ft ²	16,000 kWh
Coal	1000 lb	400 lb	52 lb Carbon/ft ²	8 tons
• Savings from 1988 U.S. Sales				
1988 U.S. Sales	2 M	8 M	120 M ft ²	6 M
\$	\$200 M	\$300 M	\$1.2 B	\$10 B
Coal (tons = T)	1 MT	1.5 MT	3 MT Carbon	50 MT
Baseload Plants (5 Bkwh/yr)	0.4	0.6	-	20
Oil platforms (10,000 bod)	1	1.5	9	50
• Savings at Saturation (Annual)				
Units in Place (1988)	600 M	~800 M	15 B ft ²	125 M
\$	\$6 B	\$6 B	\$6 B	\$10 B
Coal	30 MT	30 MT	20 MT Carbon	50 MT
Baseload Plants (1000 MW)	12	12	-	20
Oil Platforms (10,000 bod)	30	30	50	50

^aOne PL-9 replaces a series of thirteen 50W incandescents.^bLow-emissivity windows. Comparison assumes an overall weighted average improvement of 0.25 Btu/ft²-hr-°F, 6000 heating degree days, and furnace efficiency of 70%.^cComparison based on 1987 California Title-24 Standards vs. 1977 models.

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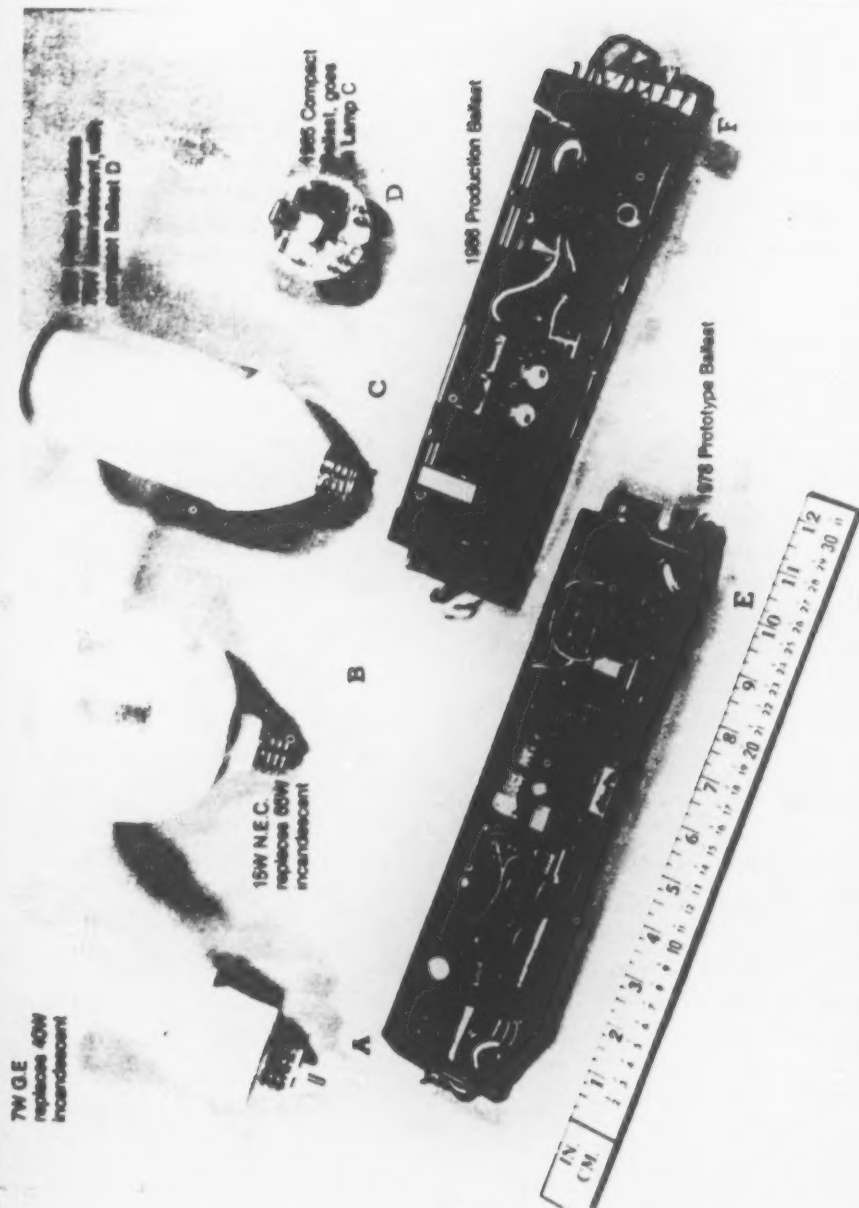


Figure 3. Progress in Fluorescent Lighting: Electronic Ballasts and Compact Fluorescent Lamps. The two ballasts shown at the bottom power two 40 W conventional lamps, and the compact ballast (D) uses the same technology to power the new compact 18W fluorescent lamps (C).

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The payback time for these windows is about 2 to 6 years depending on location.

Research on low-emissivity window coatings began at Lawrence Berkeley Laboratory in 1976. Low-e windows are to ordinary windows as thermos bottles are to glass bottles. A thermos bottle retains heat because it has two layers of glass separated by an air space⁵, as in a double-pane window, but it also has an additional opaque silver heat-mirror coating which reflects heat back inside the bottle. LBL physicists applied this concept to windows by developing a *transparent* heat-mirror low-e coating. Low-e double-pane windows have 50% better insulating properties than conventional double-pane windows. Insulating properties of windows are expressed in terms of thermal resistances or R-values: single-pane is R-1, double-pane is about R-2, triple-pane and low-e double-pane are about R-3 (for comparison the 4 inches of fiberglass in a house wall is R-11). The advantages of low-e double-pane windows are that they are better insulators, less expensive, and more light-weight than triple-pane windows, they can be selectively coated to reduce solar gain and air conditioning demand in hot, sunny regions, and they also filter out harmful ultraviolet light that can cause premature fading of carpets and drapes. Low-e windows are now commercially available and have captured nearly 20% of the residential window market.

Southwall Industries of Palo Alto, CA, who worked under an LBL subcontract in the late 1970s to commercialize residential low-e windows, is now offering special Heat-mirror™ windows for commercial buildings. Heat-mirror™ windows will work especially well in commercial buildings that experience high heating loads caused by internal heat generated by the concentration of lights, people, and equipment. Commercial buildings using these windows will be able to conserve heat on a winter night or weekend, but reflect out solar heat on a hot summer afternoon. This is why commercial buildings already have reflective "solar control" windows to reject solar heat. Before Southwall offered "tuned" windows, these solar control windows also had to reflect sunlight, making the interior space darker, and calling for more hot and expensive lighting. But now Southwall offers a perfectly transparent solar control window where the heat-mirror material has been cleverly "tuned" both to keep in room-temperature heat and to reflect out the invisible part of solar heat. This allows more visible light to enter the room allowing electric lights to be dimmed or turned off and creating a pleasant yet inexpensive office. Thus we see that selection of window options is becoming very sophisticated, and there is a need for thorough performance labels, as is fortunately provided by S. 324.

⁵Most thermos bottles actually have a vacuum between the two layers of glass. However, I use the thermos bottle analogy here as a reference to help you understand the physics behind the heat-reflective benefits of low-e double-pane windows.

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Appendix A discusses two ways to provide energy services equivalent to 10,000 barrels of oil per day. One is a coating plant for low-e windows and the other is a 10,000 barrel per day 10-well off-shore oil platform. One California company, Airco Coating Technologies, has already sold 35 of these plants. If all 35 of these plants were used to coat window glass the estimated energy savings would be equivalent to all of the oil off the California coast and in the Alaska National Wildlife Refuge. Further economics are discussed in Appendix A.

• *Super-windows*

New super-windows are currently being developed at LBL, in cooperation with major window manufacturers and utilities. These windows are an extension of low-e technology. They are expected to be about R-8 and perform better than a conventionally insulated 4 inch wall. Even on a north facing wall, where solar gains are lowest, such a window can outperform a conventional R-11 or R-15 wall during the heating season. Figure 4 compares the energy performance of a north-facing superwindow to an R-15 wall from measured data taken in Reno, Nevada. The last two days of data (days 5 and 6) were collected during completely overcast skies and very cold and snowy conditions, and this was precisely when the superwindow performed best in comparison to the R-15 wall.

• *Aerogel for Windows and Refrigerators*

Aerogel windows will quite likely become an important refrigerator insulator and form the basis for a competitive new high-tech industry. Aerogel is 95% air and 5% silica "gel", i.e. a sponge-like structure of glass that looks almost perfectly transparent. Aerogel has actually been used for a decade as a particle detector, where a slight cloudiness is acceptable. Then, in the 1980s, at LBL we developed it into a super-window, with the aerogel in a mild vacuum, which should "hold" for decades. Its thermal resistivity is an astounding R-20 per inch of thickness, compared with R-11 for the 4 inches of fiberglass in conventional walls, or with R-7.5 per inch for the foam in most new refrigerators. But since aerogel was slightly cloudy, we were pushing it only for skylights and as an insulator in architectural glass bricks. However, after the "Ozone Hole" was discovered, intense international pressure arose to phase out ozone-depleting CFCs (chlorinated fluorocarbons), and this threatened the refrigerator industry, which uses CFCs both in the insulating foams and as the working fluid in the actual compressors which chill the food. Suddenly the manufacturers were concerned that they would not be able to meet the 1993 California standards. The news here is that even at only R-20 per inch, aerogel can be one-third the thickness of the present, soon to be phased out, foams. This will allow the interior volume of a 20 cu. ft. refrigerator/freezer to increase by 2 to 3 cu. ft, and in the appliance industry, an extra 2 to 3 cu. ft. of interior space is worth about

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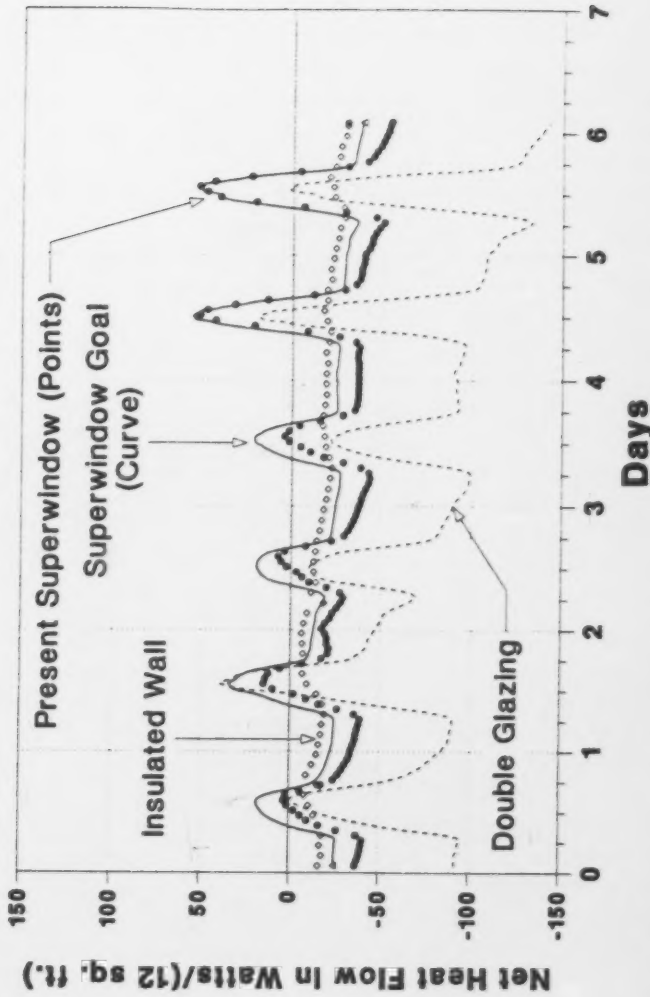


Figure 4. Comparison of Heat Gain/Loss for Three Different North-facing Windows and an R-15 Wall in Reno, Nevada, for a Winter Week. The figure shows that even north-facing in Reno, NV, superwindows can outperform an insulated wall (i.e. useful solar gain even on an overcast day averages more than steady heat loss). An insulated wall, no matter how well insulated, will always lose heat. Measured data are shown for a prototype superwindow, and the insulated wall. Calculated data are plotted for a typical conventional double-pane window and the target superwindow. The last two days of data (days 5 and 6) were collected during completely overcast skies and very cold conditions, and this was precisely when the superwindow performed best in comparison to the R-15 wall. Source: Dariush Arasteh and Joseph Klems, Windows and Daylighting Group, Lawrence Berkeley Laboratory.

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\$100 to \$150 retail. This extra profit will pay for the extra cost of the aerogel over the cheaper foam, and the consumer will still save about \$40/year of electricity, or \$800 over the life of the refrigerator. Thus we have another example of successful federal R&D which should soon become a commercial product. The latest news is that Dr. Arlon Hunt of LBL has recently discovered that he can "dope" aerogel with some trace chemicals which should almost double its insulating properties (to R-30 or R-40 per inch) but make it opaque (hopeless for windows but excellent for refrigerators).

• *Urban Trees and Light-Colored Surfaces to Reduce Urban Heat Islands*

Another interesting and recently rediscovered energy-efficiency investment option with less than a one-year payback is planting **urban trees** and introducing **lighter-colored surfaces**. Although greenhouse warming is just starting to be recognized as a real threat, most residents of large cities are already distressed by uncomfortable summer heat islands. Our research at Lawrence Berkeley Laboratory (LBL) shows that planting **urban trees** and using **lighter colored surfaces** for roofs and pavement will reduce the effect of urban heat islands *and* is also the cheapest way to save kilowatts of air conditioning power [Ak88]. Put very simply the recipe is: pay \$15 to \$75 to plant and water 3 trees around a house, wait 10 years for the trees to grow, *and* when your house needs painting or roofing use lighter-colors. Then save about 1 or 2 kW of peak power and about 750 to 2000 kWh per year in air conditioning energy per house—worth \$50-\$150 each year. Similarly, when asphalt streets or parking lots need resurfacing, they should be finished off with a thin surface of light-colored sand.

Figure 5 shows the magnitude and rate of temperature rise of the heat island in Los Angeles [Ak89]. Since 1940 summer average temperatures are up about 5 °F and are continuing to rise about one degree per decade. Combine this with global warming and the expected temperature rise could be as high as 2 °F per decade. We estimate that this 5 °F rise to date requires Los Angeles Basin utilities to supply an additional 1250 MW of peak power for air conditioning. On a hot afternoon the cost of this additional 1250 MW is about \$125,000 per hour!

Figure 6 shows that even more significant than the multi-million dollar air-conditioning costs may be the increase in smog caused by the 5 °F rise in temperature rise. We see that LA never experiences smog episodes below 74 °F, but by 94 °F smog has become more or less unbearable. Of this 20 °F window between onset of smog and unacceptability the heat island seems already responsible for 5 °F and is headed for 10 °F. Fortunately we now understand enough about the causes of this heat island to undo it, and return Los Angeles and all American cities to pre-1940 summer temperatures.

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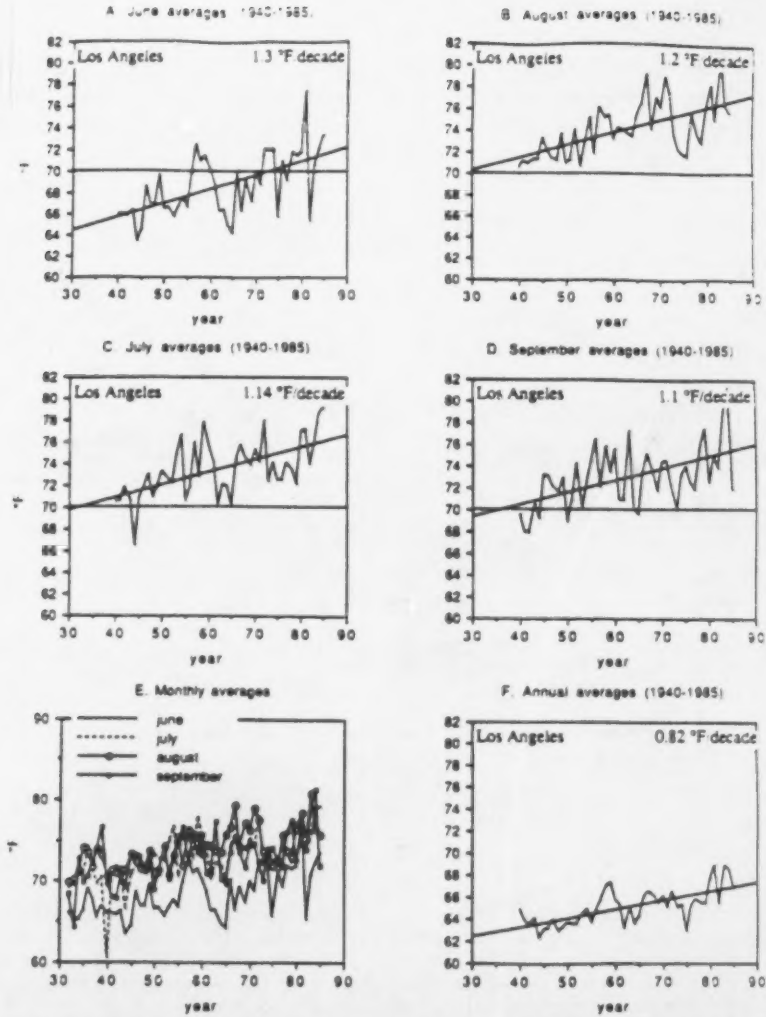


Figure 5. Monthly and average Temperature Averages for Los Angeles (1940-1988). The top four graphs are based on monthly averages for June, July, August, and September. The four plots have remarkably similar slopes of about 0.12 °F/year. From 1940 to 1988 (48 years) we see a warming trend of about 6 °F, and this will hit 10 °F in another 30 years [Ak89].

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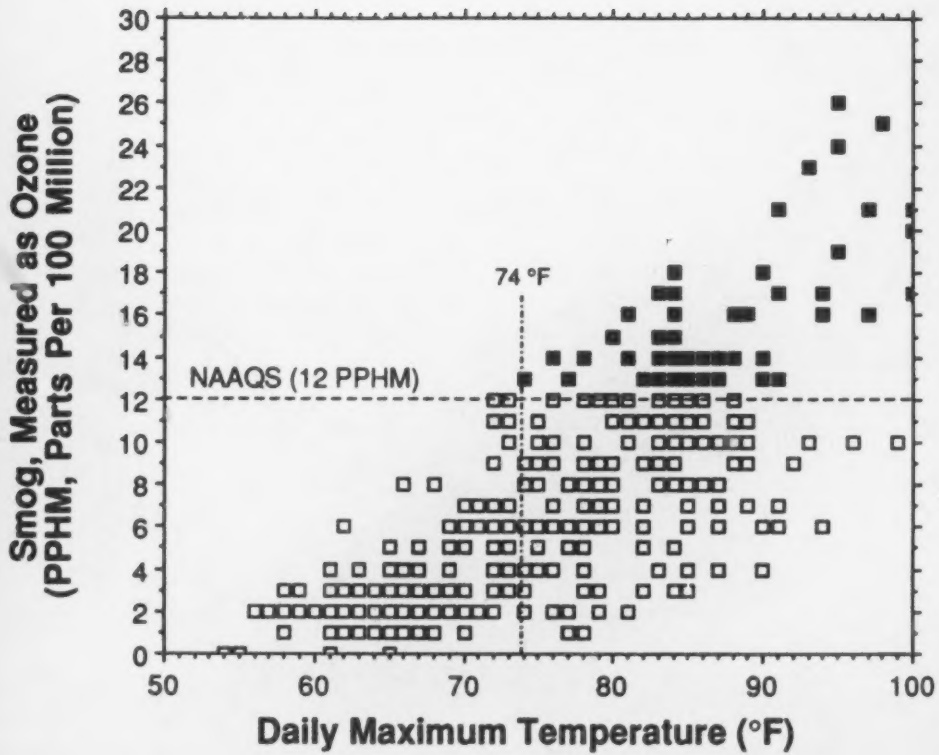


Figure 6. Los Angeles Smog Concentration Measured as Ozone in PPHM (Parts per Hundred Million) at North Main Street (1985 Data). The horizontal line marks the National Ambient Air Quality Standard (NAAQS) for ozone of 12 PPHM, and shows that Los Angeles never experiences smog episodes when the daily maximum temperature is below 74 °F. However, when the temperature is greater than 94 °F the smog is more or less unbearable. Source: Laura Wilson, University of California, Berkeley data from CA85, US85.

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3. Priorities

The first priority of an organized, well-planned national energy policy should be to promote energy efficiency improvements in transportation, industry, and buildings. The policy proposals outlined in S. 324 will do this. However, a gasoline tax and/or fee/rebate program for new cars based on fuel efficiency is sorely needed to motivate consumers to purchase more fuel efficient cars. Additionally, a CO₂ emissions fee/rebate program for electrical utilities would help motivate utilities to switch to conservation and renewable energy supply.

The second priority should be to strengthen existing energy efficiency research and development programs. In my field of expertise—buildings—it is my opinion that the R&D budget proposed in S. 324 is far too small. The FY 89 DoE budget for Buildings and Community Systems was \$33 million. The FY 90 budget request is about half that, but the Congress has usually restored much of the proposed cuts. For FY 91 S. 324 proposes \$58 million; but for the reasons I outline below, taking into account the short payback times available for improving buildings, and the buildings trade deficit,—which has now reached \$6 billion annually—total buildings R&D in the U.S. should be much higher.

The annual energy bill for buildings is about \$150 billion per year, and since spending on R&D by mature industries in the U.S. is about 1%, one could argue for a buildings energy R&D budget of about \$1.5 billion. Instead R&D on energy efficiency in buildings is only about \$35 million from DoE, \$75 million from the Gas Research Institute (GRI), \$35 million from the Electric Power Research Institute (EPRI), and almost no private funding anymore except for the appliance industry, which ploughs back about 1% of its revenues. The total is then about \$150 million compared with annual energy bills of \$150 billion, or one part per thousand. This sad story has two causes:

1. The buildings industry is extremely fragmented. There are no industry leaders who see themselves as being able to support the R&D for such a huge sector, and
2. Historically, there has been no foreign competition, so the industry has not seen the need to organize itself to support collaborative R&D, as has the gas industry with GRI and the electric industry with EPRI.

This is a related comment that is somewhat more general than the scope of S. 324. I am concerned that it costs us one-fourth of our GNP—\$1 trillion per year—to live and work in buildings and pay for them, yet we invest a total of only about \$600 million per year in Federal plus private R&D. This is 0.6 parts per thousand! Underinvesting in R&D is already hurting us. Figure 7 shows export-import trends over the past 6 years in the buildings products, wood products, and appliance industries. The trade deficit in 1987 alone was over \$6 billion, and we are now seeing whole housing developments using considerable foreign content.

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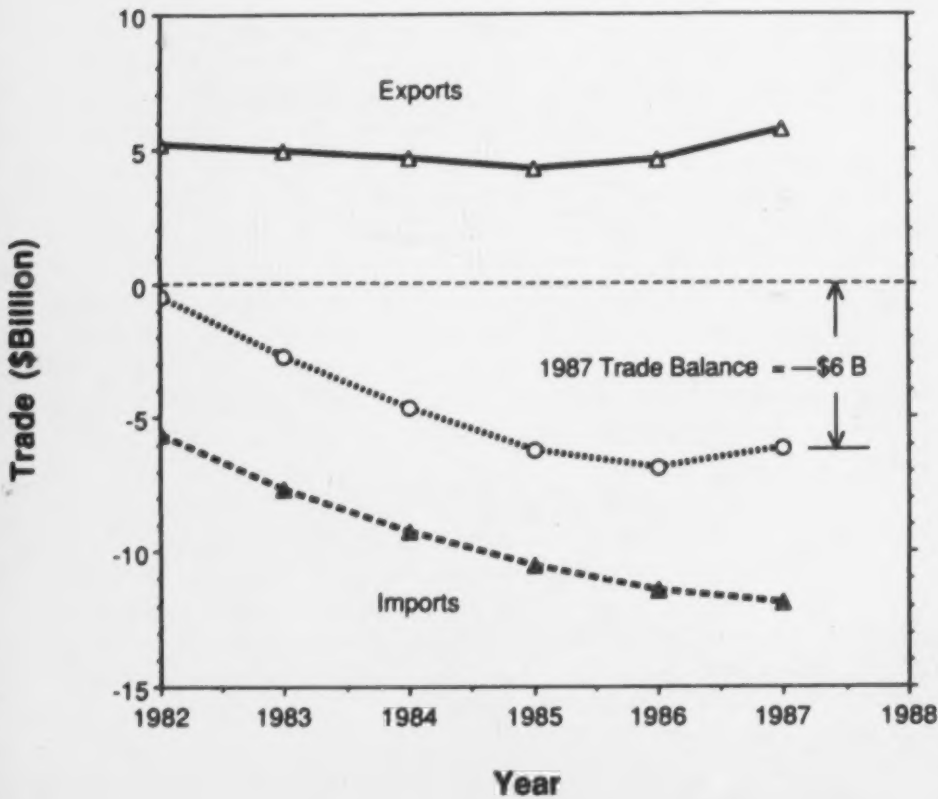


Figure 7. Balance of Trade for Selected U.S. Building Components (1981-1987). The figure shows the growing trade deficit in the buildings components sector of the U.S. economy. The trade deficit is actually larger since the figure does not include Heating, Ventilating, and Air Conditioning, Paints, Chemicals, Sealants, and Electrical Products. Source: David Engel, U.S. Housing and Urban Development from U.S. Dept. of Commerce data.

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You can already call (800) numbers for turn-key Japanese and Korean office buildings. If we are to remain competitive in the huge buildings sector we must invest in buildings R&D now or lose out to foreign competition.

I would also like to make one small comment on Title XII—Basic Science Initiatives. S. 324 calls out NASA, NSF, NOAA, USGS, and NIST, and raises their budgets. I approve. But EPA, DoE, and the National Laboratories are already heavily involved in climate research related to greenhouse warming, and I think it would cause some confusion if they were not also mentioned.

4. Conclusion

In recent years U.S. government support for energy efficiency R&D has dwindled. Private industry has also relaxed its interest in energy-efficiency R&D, due to low oil prices. This will have an adverse effect on the U.S. economy and national security. Abandoning or deferring R&D investments needed now will hurt long-term U.S. competitiveness because of the long lead-times, 20 years or more, for development and commercialization and saturation of advanced energy-saving technologies. Increasing reliance on imported oil and will eventually lead to another oil crisis and attendant national security problems. Additionally, the serious consequences of continued high levels of fossil fuel consumption will add to global warming and further degrade the environment.

In the U.S. the scale of the problem is impressive given the sheer numbers of energy-using facilities, equipment, and components that are built and sold each year, many with expected lifetimes of 10 to 50 years. Just in the buildings sector, annual additions to the stock include 8 million refrigerators, 2 million single-family and multi-family dwellings, and 1 billion square feet of commercial building space. Improving energy efficiency will require a strong and sustained government commitment to R&D, technology transfer, and the development of effective market-enhancing energy policies. The successes mentioned in this testimony are only a beginning compared to what could be done if the U.S. applied its full technical prowess to creating an energy-efficient, sustainable future.

Acknowledgment

I would like to thank Robert Mowris for his help with research and editing.

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March 14, 1989

A. H. Rosenfeld

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Conservation Research Note

May 1988

from the Center for Building Science / Lawrence Berkeley Laboratory

New Energy Supply Technology for the 21st Century

High Tech Window Coatings "Supply" Energy Services

Buildings account for over one third of all U.S. energy consumption. Energy policy has emphasized the development of new secure energy supply options such as off-shore oil. But advanced building technology that effectively reduces the need for current consumption can also be viewed as a supply option.

Consider the following two choices for "supplying"
\$1 billion of energy services:

Low-E Window Technology

Heat loss from windows is responsible for about 4% of total U.S. energy consumption, or the equivalent of 1.4 million barrels of oil per day. Transparent low emissivity (low-E) coatings provide one third reductions in window heat loss.

This industrial low-E coater (See *Recipe 1*) can coat over 20 million square feet of glass for windows each year. Savings accumulate rapidly since each window continues to save energy over its entire lifetime, at least 20 years.

Offshore Oil Wells

Oil under the continental shelf is a secure, but environmentally fragile, costly and depletable supply option. (See *Recipe 2*).

Recipe #1**Low-E Window Technology**

- Step 1:** Invest \$8 million in a low-E coating system.
Step 2: Coat 20 million square feet of windows per year for the 10 year nominal life of the coating system.
Step 3: Accumulate energy savings over the 20 year life of the window.
- Step 4: RESULT:** Savings of 36 million barrels of oil equivalent!



Figure 1

Glass coaters such as this high-rate sputtering system can coat large sheets of glass with sophisticated multilayer coatings for control of heat and light in buildings.

Photo courtesy of Airco Solar Products, Concord, CA.

Recipe #2**Offshore Oil Wells**

- Step 1:** Invest \$300 million in a 10 well offshore oil platform, producing 10,000 barrels per day.
- Step 2:** Pump oil for the 10 year nominal life of the oil field (don't spill a drop).
- Step 3:** **RESULT:** Supply of 36 million barrels of oil!



Figure 2

An oil company's 10,000 barrel/day, 700 foot-high, \$ 300-million platform off the Santa Barbara, California coast.

The Economics of Payback Times

Thirty-six million barrels of oil equivalent saved by low-E is worth more than \$1 billion of home heating oil, natural gas, or electric resistance heat.

The simplest economic measures of energy efficiency investments are **simple payback time**, or **cost of conserved energy**.

Low-E glass adds about \$2.00 per square foot cost to a new window, but pays back **this investment in 2 to 6 years** depending upon climate and energy costs. Coated glass cost may be reduced in the future, thereby further shortening the payback. The **cost of energy conserved** by a low-E window is 40 cents per therm of gas (current price, 60 cents per therm) or 54 cents per gallon of home heating oil (current price, 80 cents per gallon), or 2 cents per kilowatt for electric resistance heat (current price, 7.5 cents per kilowatt).

These energy conservation strategies are good investments for consumers, help strengthen U.S. industry and reduce our dependence on foreign oil.

For more information about low-E windows, contact your local building materials supplier, window manufacturer, or architect/builder.

For more information on the economics of energy conservation or other research notes in this series, contact:

American Council for an Energy-Efficient Economy
1001 Connecticut Avenue NW, Suite 535
Washington, DC 20036
(202) 429-8873

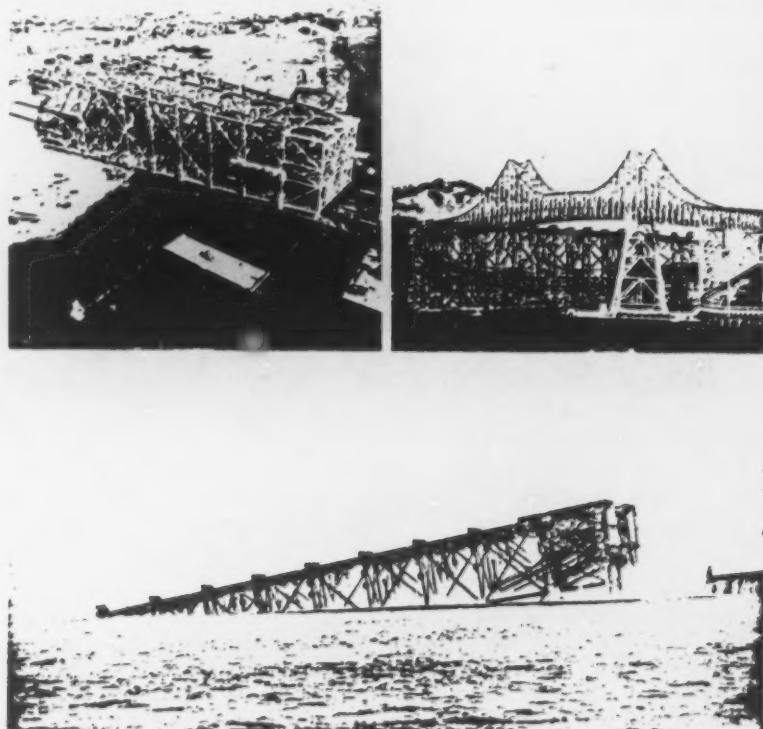


Figure 3

Recalling a Fastastic Voyage

With a length of over two football fields, Shell Oil Company's Eureka Oil Platform was placed on its side for a voyage in 1984 to a site off the Santa Barbara Coast on the California Outer Continental Shelf. In order that it pass under the Carquinez Strait Bridges, spanning the Sacramento River as it enters San Francisco Bay, the engineers had to time the platform's departure to correspond with the lowest tide, allowing it to safely clear the bridge's roadbed.

The completely outfitted 38,000 ton Eureka platform was lowered into 700 feet of water. A 24 inch diameter hole has been drilled to a depth of 200 feet below the ocean floor, directly below the platform. From this central hole, 60 off-angle wells (conductors) have been drilled to form a grid of holes that enter the oil reservoir.

Selected Energy-efficient Technologies: Current Savings and Predicted Savings at Saturation.

	Solid-state ballasts	Compact Fluorescents (PL-9) ^a	Windows Low-E ^b	Refrigerators ^c 1987 California Title 10
• Life	35,000 hr	10,000 hr	30 yr	20 yr
• Cost Premium	\$12	~0	0-\$1.00/ft ²	\$100
• Lifetime Savings per unit				
\$	\$100	\$40	\$10/ft ²	\$1600
Energy	1000 kWh	400 kWh	1.5 M Btu/ft ²	16,000 kWh
Coal	1000 lb	400 lb	52 lb Carbon/ft ²	8 tons
• Savings from 1988 U.S. Sales				
1988 U.S. Sales	2 M	8 M	200 M ft ²	6 M
\$	\$200 M	\$300 M	\$2 B	\$10 B
Coal (tons = T)	1 MT	1.5 MT	5 MT Carbon	50 MT
Baseload Plants (5 Bkwh/yr)	0.4	0.6	-	20
Oil platforms (10,000 bod)	1	1.5	15	50
• Savings at Saturation				
Units in Place (1988)	600 M	~800 M	15 B ft ²	125 M
Annual \$	\$6 B	\$6 B	\$6 B	\$10 B
Coal	30 MT	30 MT	20 MT Carbon	50 MT
Power Plants (1000 MW)	12	12	-	20
Oil Platforms (10,000 bod)	30	30	50	50

^aOne PL-9 replaces a series of thirteen 50W incandescents.

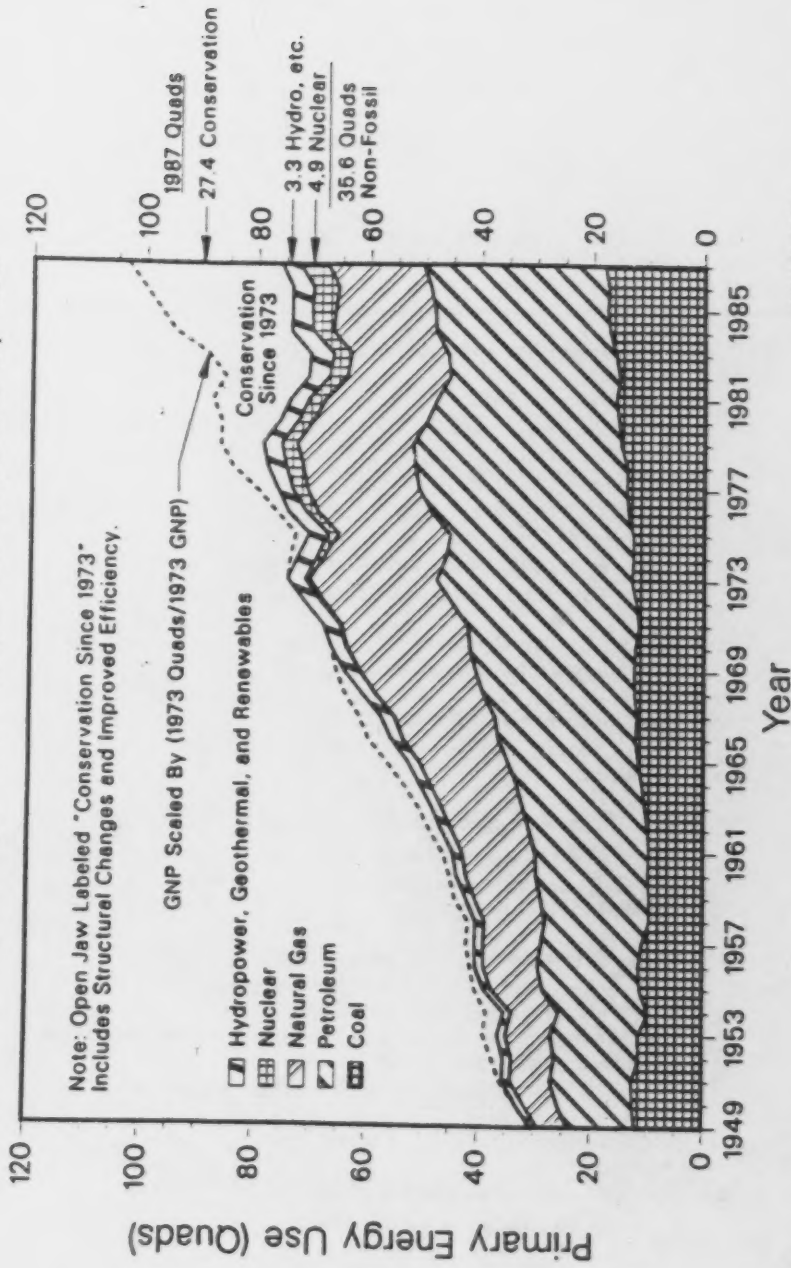
^bComparison assumes an overall weighted average improvement of 0.25 Btu/ft²-hr-°F, 6000 heating degree days, and furnace efficiency of 70%.

^cComparison based on 1987 California Title-24 Standards vs. 1977 models.

Source: Geller, H, Harris, J., Levine, M., Rosenfeld, A., "The Role of Federal Research and Development in Advancing Energy Efficiency: A \$50 Billion Contribution to the U.S. Economy", *Annual Review of Energy*, 12:357-395, 1987.

Some Conversions: One Baseload gas- (or oil-) fired 1000 MW power plant consumes the equivalent output of 2.7 offshore oil platforms (10,000 bod/platform). Mendocino plus Humbolt Leases call for 10-20 platforms. The Alaska National Wildlife Refuge could yield 30 equivalent oil platforms.

U.S. Primary Energy Use: Actual vs. Predicted by GNP



XCG 884-RJM
4/30/88

Source: Economic Report of the President, Council of Economic Advisors, January 1988, and Annual Energy Review 1987, EIA

PROPOSED ENERGY POLICY

1. Improve efficiency 3.5% each year for the next 20-40 years

This doubles efficiency every 20 years.

2. Promote our new efficient products in both the industrial world and the 3rd world.

If industrial GNP's continue to grow 2.5%/yr, we'll reduce fossil fuel use about 1%/year (halving time 70 years). That might keep WORLD fossil fuel consumption growth down to 1%/year.

Energy Conservation Policies for the US and OECD

1. Change National Policy

Encourage Least Cost Energy Services. Level the supply-demand playing field [10-year payback for supply vs. 2-3 year for demand].

Stop opposing auto and appliance standards with 3-year payback.

Stop cutting R&D budgets and consumer information.

Extend the time horizon for capital gains taxes.

2. Redefine Utility Profits To Make Least Cost Energy Services More Attractive Than Just Selling Energy

3. Buildings (State and National)

Sliding Scale hookup fee/rebate. \$1000/kW, revenue neutral.

4. Autos (State and National)

Slowly raise gasoline tax to \$1/gal.

Immediately introduce a new car efficiency fee/rebate; \$200/mpg, revenue neutral.

5. CO₂ pollution rights, with rebate (State or National)

1-2¢/lb of carbon = 1-2¢/kWh generated from coal, ½-1¢/kWh generated from natural gas. No fees or rebates cross state lines, so no threat to coal-use states; merely encourages efficiency and reduces fossil fuel use.

Charge fee per pound burned, rebate per customer. Fees to be determined by a pollution rights market or auction with a goal to reduce CO₂ by 1%/year.

- 5a. SO_x and Other Pollution Rights

Same machinery but cut SO_x faster.

Source: A. Rosenfeld, R. Mowris, and J. Koomey, "Energy Efficiency and Least Cost Planning," Comments for the California Energy Commission, August 17, 1988.

Senator WIRTH. Thank you, Dr. Rosenfeld.
Mr. Wolf.

**STATEMENT OF JAMES L. WOLF, EXECUTIVE DIRECTOR, THE
ALLIANCE TO SAVE ENERGY**

Mr. WOLF. Thank you very much, Mr. Chairman. I am here today representing The Alliance to Save Energy, which I know you are intimately familiar with as our chairman, but for those who are not familiar with the alliance, as you know, we are a coalition of government, business and consumer leaders dedicated to energy efficiency. And we conduct research and pilot programs to achieve this goal.

My testimony today will be based upon our extensive field work and a recent survey we conducted of firms, industrial organizations, engaged in energy conservation R&D. And I am pleased to submit our results of that survey with my testimony.

We commend what we see as the two-pronged strategy of S. 324 on energy efficiency, first, facilitating and fostering the conservation marketplace and, second, expanding conservation research and development activities. If as Senator Fowler called the Amazon is the lungs of the world to prevent the global greenhouse, we perceive energy efficiency as really the heart of any strategy to also prevent that greenhouse effect.

In terms of fostering the conservation marketplace, S. 324 contains many provisions that we think promote the adoption of cost-effective conservation technologies in the marketplace. I will briefly mention two provisions that we have been active on.

One is home energy rating systems. We view this as an integral component to foster the conservation marketplace both from the homeowner, and particularly from the financing secondary mortgage market aspect. Energy costs are the largest costs of home occupancy after your rent or mortgage payments. Making homes energy efficient using some of the technologies that Art has demonstrated will make housing more affordable for 2 million more American families.

We do put energy labels on automobiles. We put them on our major appliances. We believe it is time to put energy labels on the consumers' largest energy user, which is their home.

Many home energy rating systems currently across the country, Alabama Power Company, the City of Austin, Texas, and a variety of private home energy rating systems have started. But they really have not achieved their maximum effectiveness, however, because we must ensure that builders, consumers, buyers and lenders all have a financial incentive to promote efficiency.

The problem with many of the home energy rating systems is they are not coordinated with the secondary mortgage market. And we want to see a financial incentive for homeowners to buy efficiency. And we believe your legislation will accomplish this by linking home energy rating systems to the major mortgage financing institutions, Fannie Mae, Freddie Mac, FHA and VA, all of whom have programs now to promote energy efficiency, and we think this will significantly facilitate their adoption.

The second provision that we believe will significantly foster the conservation market Ralph Cavanagh has emphasized, which is utility regulatory reform. In a study we at the Alliance conducted, we found that 70 percent of the cost-effective opportunity for conservation will not be achieved by normal market forces. This may be due to failures of information, failures of finances or others.

In our report we examine the ability of utilities to rate-base, to earn a rate of return on their conservation expenditures. I think it is important the committee and others recognize that most utilities in this country currently expense their expenditures on conservation. This means they get them back from their ratepayers in the form of increased rates perhaps, but they do not earn a rate of return on these expenditures. But even rate-basing conservation expenditures will not truly level the playing field. Utilities will not be compensated for the revenues they lose by promoting conservation.

What your legislation establishes is the goal for society that utilities least-cost plan must be their most profitable plan. And we think that is a commendable goal.

I point out to the people we deal with in the utility industry that this principle, the least-cost plan being the most profitable plan, should be consistent with new applications of electric and gas technologies, as well as the promotion of conservation because many of the new technologies that use either electricity or gas have several benefits because they be in the form of improved product quality, higher productivity or lower CO₂ emissions.

The second part of the bill on energy efficiency that we endorse is, needless to say, the expanding of conservation research. Art has pointed out many of the benefits that have already been achieved by current cost-effective conservation technologies that have been promoted and developed in conjunction with the national laboratories.

One point in response to Senator Rockefeller and others that I think is important is that the development of new technologies is why the boundary for cost-effectiveness of conservation is ever-expanding. When we look in the year 2000 and beyond, we should not just assume that we only have available to us the cost-effective conservations that we have today. We need to continue to research to expand the boundary of cost-effectiveness in part to stimulate and achieve economic growth.

In the survey that we recently conducted at the alliance we wrote many of the firms currently engaged in Federal R&D. These include lighting manufacturers, ceramics, insulation, gas and electric utilities, HVAC, as well as the transportation industries. We posed nine specific questions to them concerning coordination of Federal R&D, the emphasis of Federal R&D, patent rights, anti-trust questions, as well as why many of the products were seemingly produced only overseas after being invented here.

Three key findings emerged from this survey: first, the need for DOE to expand its concept of the appropriate role for Federal funding far beyond the basic research stage to support of demonstration and commercialization activities; second, the need for the government to foster the energy efficiency market through a technology purchase program; and finally, the need to reexamine the role of

DOE, the national laboratories and private industry and to do a better job of tech transfer to industry.

The first finding is the support of the demonstration projects and commercialization activities. Currently the emphasis of DOE funding is on long-term basic research. Funding for specific products, demonstration and commercialization activities have significantly decreased. In part, this has resulted in many of the products being researched and invented here commercially being produced only overseas. DOE can address these problems. However, it will be a significant departure from current practice.

We believe your section 303 in the bill calling for demonstration is a major step in this direction. We recommend that the cost-sharing requirements in this bill be reviewed. Many industry executives suggested that cost-sharing is a major barrier to the successful demonstration. In addition, many suggested that not all the proposals should be done in response to an RFP, but that some should be done on the basis of unsolicited proposals.

You had asked what President Bush—and I also want to respond to that—could do. And we have often heard—I think President Bush is known for at least two phrases one is to read his lips. The other is the thousand points of light. I can't resist and I'm sure Art will pick up on this that we should make sure that those thousand points of light are energy efficient bulbs. And I know you are working with the architect of the Capitol here, so we can start that program here as the President gets it underway nationwide.

The second strong finding from the survey that we found is the need for government to be a purchaser of energy efficient technologies. It is frankly folly that in many of the R&D programs we are doing with the national laboratories, we fund the R&D and then let the technology wither on the vine. The Federal Government is the largest energy user in the country. It's annual energy bill is over \$8 billion, and that is just for buildings and transportation equipment. We need to look at in the context of the R&D funding purchases of that technology when developed for both purchase of demonstration, as well as to assist in the commercialization.

I make an analogy to the Defense Department's DARPA program which has gotten much attention in the context of high definition television. If we are developing high definition TV in the Defense Department because they believe it will help future defense needs in terms of their monitoring and computers, shouldn't we also be looking at that in the context of our DOE funding, GSA funding of R&D and then having a guaranteed market available for these products when they are developed.

In addition, even DARPA, if they are concerned about the future defense needs of the country, we well know the national security concern about reliance on imported oil. They could even consider developing themselves and funding themselves some basic research on conservation and efficiency technologies.

Section 305 in the legislation which calls for a Federal energy management team I recommend be expanded to include some specific provisions for Federal purchases of the technology developed.

Finally I will just mention the third finding about the roles of the Department of Energy and the national laboratory. I think we need to clearly articulate to industry and get them more involved,

what are the purposes of Federal programs, how do they coordinate with industry. I commend to the committee—Eric Hurst last week in February 28 testified before the House Science and Technology Committee and made some specific recommendations about an appropriate Federal role in research and development and how the role of the national laboratories could also be expanded.

I believe Title IV of your bill which establishes R&D priorities could be used as the first basis for this ongoing discussion with industry to get them more involved in an articulation of appropriate role and better tech transfer.

I conclude, Mr. Chairman, with a strong endorsement of S. 324 not only to address—and believe its energy efficiency provisions will not only address the greenhouse, but will significantly assist on the other major issues you identified of competitiveness, affordable housing and national security.

Thank you.

[The prepared statement of Mr. Wolf follows:]

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Executive Director

**Testimony of
James L. Wolf
Executive Director
The Alliance to Save Energy**

**on S. 324
The National Energy Policy Act of 1989**

**before the
U.S. Senate Committee on Energy and Natural
Resources**

March 14, 1989

Testimony of James L. Wolf
Executive Director
The Alliance to Save Energy
before the
U.S. Senate Committee on Energy and Natural Resources
March 14, 1989

I appreciate the invitation to testify before the Committee regarding energy efficiency as it relates to S. 324, the National Energy Policy Act of 1989. The Alliance to Save Energy is a national nonprofit coalition of government, business and consumer leaders dedicated to increasing energy efficiency. We conduct research, pilot projects, educational programs and policy advocacy to achieve this goal.

My testimony today is based upon the extensive field work we do in testing new technologies and working with organizations to design programs to facilitate their introduction into the market. It also is based upon a recent survey we conducted of firms engaged in federal conservation research and development activities. I am submitting with this testimony a copy of the results of that survey.

We commend the two-prong strategy that S. 324 contains on energy efficiency -- first, provisions to foster the conservation market and second, provisions to expand conservation research and development activities.

FOSTERING THE CONSERVATION MARKET

The bill contains many provisions which will accelerate the adoption of cost-effective conservation technologies in the marketplace. I will briefly discuss two provisions which concern projects the Alliance is conducting.

Home Energy Rating Systems:

A significant provision in the bill to promote the adoption of cost-effective technologies calls for home energy rating systems. Providing the consumer this type of reliable, easy to understand information can be one of the government's most important roles.

After rent or mortgage payments, energy costs are the largest cost of home occupancy. Energy efficiency can significantly improve housing affordability and make housing more affordable for two million more families.

Energy labels on homes will promote a market in efficiency. We require energy labels on automobiles and major

appliances. Now is the time to put energy labels on consumers' biggest energy users -- their homes.

Dozens of pioneers have set up home energy rating systems. These include utilities, such as Alabama Power Company which has rated more than 12,000 homes that use 50% less energy than conventional models, and TVA's Energy Saver home which uses 40% less energy than previous designs. The city of Austin, Texas has a program which is used by two-thirds of the city's builders. And a nonprofit organization, Energy Rated Homes, is helping several states and localities implement rating systems.

For a rating system to be effective, however, we must ensure that builders, realtors, buyers and lenders have financial incentives for efficiency. The Alliance assisted the secondary mortgage market design programs to facilitate financing the purchase of an efficient home or improvements to an inefficient older one. These programs are not, however, widely used or promoted at the local level because the rating systems being implemented vary significantly and do not coordinate with the secondary market.

This legislation will link home energy rating systems to the major mortgage financing institutions -- Fannie Mae, Freddie Mac, FHA and VA. It will enable the policies these institutions have for encouraging energy efficiency to effectively influence the market. It will enable buyers of efficient homes to qualify more easily for mortgages, which will encourage the shelter industry to build these types of homes. It will also let buyers of less efficient older homes upgrade them through mortgage financing, reducing their total housing costs.

Utility Regulatory Reform:

The potential for society to achieve more cost-effective conservation is vast. In a study the Alliance conducted in cooperation with a major utility, however, we found that 70% of the cost-effective opportunities to society for conservation investment will not be realized through the operation of market forces alone. This conservation potential was equivalent to 15% of total electricity consumption for that utility, and approximately 600 MW of summer peak demand. We found that utilities are uniquely suited to influence customer's investment decisions through financial incentives.

Many utilities are implementing programs to promote investments in efficiency by their residential, commercial and industrial customers. This in part due to least-cost planning procedures that are being required by many States. Even least-cost planning, however, does not ensure we will achieve the goal of a utility aggressively pursuing all

cost-effective conservation. This is partially due to the financial impacts of conservation on the utility.

In a report the Alliance recently issued, Ratebasing of Utility Conservation and Load Management Programs, we recommended that utilities be allowed to ratebase and earn a rate-of return on their expenditures on conservation just like they do on investments in traditional supply-side sources. Most utilities presently "expense" these expenditures on conservation -- recovering them from their customers through rates -- but they do not earn a rate of return on them. We noted, however, that even ratebasing would not compensate utilities for the revenues they lose for conscientiously seeking out and implementing cost-effective conservation or efficiency improvements in their customer's facilities.

We need to establish the principle for society that the utility's least-cost plan should be its most profitable plan. This principle should be consistent with both promotion of new applications of electric and gas technologies and promotion of conservation. Many new applications of electric and gas technologies have several benefits -- from improved product quality to higher productivity to lower CO2 emissions than the technology it replaces.

S. 324 establishes this principle for utility regulation, and allows States the flexibility to devise regulations to achieve this objective. By adopting this provision we will not discourage a utility from promoting new applications of electric or gas technologies; we will significantly enhance the market in conservation and efficient technologies.

EXPANDING CONSERVATION RESEARCH

The Alliance has a unique perspective on energy conservation R&D. We have participated in many field tests to evaluate new technologies. We work with the Department of Energy, the national laboratories and private industry to conduct these programs, as well as others. Some of our work has been funded by the Department of Energy.

Many of the technologies that are now standard -- such as flame retention oil burners that save over 20% from earlier models -- were invented by private industry in successful collaboration with the national laboratories. There are numerous examples of federal investments in research and development that have resulted in energy efficient products -- benefiting both our national security and the environment.

We can make significant strides today by programs to promote the use of existing cost-effective technology. But we must continue to research and develop new technologies for tomorrow. Development of new technologies is one reason why the boundary of cost-effectiveness for conservation is ever expanding. Our challenge is to continue to expand the frontier as the economy grows and existing technologies achieve their market potential.

Survey of Industry

The Alliance recently surveyed senior executives of organizations engaged in federal conservation R&D. Over 30 executives responded to the questions, and a copy of the report analyzing their responses is attached to my testimony. The responses are very informative from a qualitative perspective but do not represent a statistical sampling.

Three key findings emerged from the survey. First, DOE should expand its support of demonstration and other commercialization activities. Second, the federal government should foster the market for energy efficiency technologies through a purchasing program. Finally, while there is strong support for a significant federal role in R&D, the roles of DOE and the national laboratories in conservation R&D should be reviewed, clearly articulated, and communicated to industry. The findings do suggest modifications to some specific provisions of S. 324.

DOE should expand its support of demonstration projects and other commercialization activities. Since 1981, DOE's conservation R&D efforts have concentrated on long-term basic research on generic technologies; funding for specific products and demonstration-oriented activities has diminished. New energy efficiency technologies that have been funded through the proof-of-concept stage often never make it to the market because of the high costs and risks of commercialization. In some cases, these concepts are picked up and commercialized by overseas competitors. As a result, the U.S. lags in getting new energy-efficiency technologies into production.

As one executive noted in response to the survey: "In the development of a new technology or product there is a continuum of activity: basic research, applied research, laboratory model, proof-of-concept unit, field test units, pilot production and full scale production. . . . The technical risk is reduced as one goes from step to step but the economic investment increases in each progressive step. . . . There is often a funding gap between the feasibility development and product development." It is especially difficult for smaller firms to raise the capital to complete the cycle of full scale commercialization.

DOE can address these problems by providing strong and stable funding for demonstration and commercialization activities. This would be a significant departure from current practice. While industry should be expected to contribute financially to these projects, the cost-sharing requirements should be eased for smaller firms -- perhaps through a mechanism that would recapture the government's investment after a product is successfully commercialized. Section 303 of the bill accomplishes many of these objectives. However, the cost-sharing requirements should be reviewed.

Another provision in Section 303 that should be reexamined is the requirement for requests for proposals. Because of the complexity and expenses involved in responding to requests for proposals, many firms -- particularly smaller ones -- noted that reserving a portion of the funds for unsolicited proposals would be very beneficial. It would both encourage innovative proposals and facilitate these firms participating in federal R&D.

The perceived need for federal participation in demonstration and commercialization activities is resounding from the survey.

The federal government should help foster the market for energy efficiency technologies through a purchasing program. Many firms noted that the government is a massive consumer of energy-related technology, but does not use its purchasing power to assist in the market development of efficiency innovations that have been nurtured through federal R&D funding. The comments received are more significant than just the general lament about the state of federal energy management.

In this context, it is helpful to make an analogy to the Defense Advanced Research Projects Agency (DARPA) within the Department of Defense. This program is working with industry to support development of technologies critical to future identified defense needs. The firms have a market for their product when it is developed. As has been observed by many, the technologies will have significant benefits in the civilian sector as well. DARPA is able to accelerate introduction of products to the civilian sector both because of the R&D funding support and the knowledge that a receptive market for initial product sales exists.

Despite the vast need for improvements in federal energy efficiency, and the money allocated for research, there is no consideration given during the R&D funding decisions to the purchase of the technology developed. This clearly should be remedied by DOE working with GSA.

Even DARPA may have a role in energy efficiency. If DARPA's focus is technologies critical to our national defense, does not energy efficiency fit within that category? We well know the threat to our security posed by excessive reliance on imported oil. Reducing that dependence could be an important component of DARPA activities -- the Department of Defense is, after all, the largest energy consumer in the country.

Section 305 of the legislation which establishes a team to review federal energy management should be amended to include specific provisions providing for some form of ready access to the federal market for products developed with federal R&D funds.

The roles of DOE and the national laboratories in conservation R&D should be reviewed, clearly articulated and communicated to industry.

There was strong support for a significant -- even expanded -- federal role in R&D. However, many firms indicated that they do not have a clear understanding of DOE's program goals or current R&D activities. The process by which broad goals are translated into program and funding priorities is unclear. Differences between societal goals -- such as national security and environmental quality -- and the private sector's goals must be recognized in program design. DOE should work more closely with industry and the national laboratories to determine the scope and direction of R&D, and to ensure the results of the laboratories' work are transferred to industry.

Title IV -- Energy Research and Development Priorities -- of S. 324 establishes R&D priorities for all the research programs being conducted by the Department of Energy. The criteria in that title should be a focal point for the discussions that must begin between the Department and industry.

The management direction of DOE's programs must ultimately reside with DOE officials and not private industry. It is clear, however, that industry needs to be more involved in advisory councils and other types of programs. Only then will our national laboratories, the Department and industry be able to cooperatively work together and maximize the benefits we can achieve from federal R&D.

CONCLUSION

S. 324 will significantly improve the market for energy efficiency. It will accelerate the adoption of current cost-effective conservation technologies. It will enhance research to develop new products and assist their introduction into commercialization. The benefits our country will receive include not only a major step in

mitigating the threat of global warming, but also enhanced national security, more affordable housing, and a more competitive economy.

**The Department of Energy's
Conservation R&D Programs:
Results of a Survey of Industry Leaders**

**The Alliance to Save Energy
March 1989**

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THE DEPARTMENT OF ENERGY'S CONSERVATION R&D PROGRAMS:
RESULTS OF A SURVEY OF INDUSTRY LEADERS

The Alliance to Save Energy
March 1989

EXECUTIVE SUMMARY

The Alliance to Save Energy solicited the opinions of industry leaders regarding the the Department of Energy's energy conservation R&D programs. We sent a list of nine questions to senior executives of private companies and industry-funded organizations that have participated in, or have direct knowledge of, DOE-funded R&D projects. The questions addressed the proper role of the federal government in funding R&D, the extent of coordination of federal programs with industry initiatives, the structure of the DOE programs, and priorities for funding. Questions also asked for views concerning the slow market penetration of energy efficiency technologies and the tendency for such technologies to be produced overseas.

Responses were received from persons in 31 organizations, primarily private companies, ranging from small, entrepreneurial ventures to large multinational corporations. Recipients of funding from all of DOE's four conservation R&D offices -- Buildings and Community Systems, Transportation Systems, Industrial Programs, and Energy Utilization Research -- were represented among the respondents.

In general, industry leaders are strongly supportive of DOE's conservation R&D programs. Three key recommendations for improvements in the program emerge from their responses:

- DOE should expand its support of demonstration projects and other commercialization activities. Some new energy efficiency technologies that have been funded through the proof-of-concept stage never make it to market because of the high costs and risks of commercialization. In some cases, these concepts are picked up and commercialized by overseas competitors. DOE can address these problems by providing strong and stable funding for demonstration and commercialization activities. Recipients of R&D funding should be expected to cost-share on a flexible basis. A portion of demonstration funding should be reserved for unsolicited proposals.

- The federal government should help create a market for energy efficiency technologies through a purchasing program. The government does not use its purchasing power to assist in the market development of efficiency innovations that have been nurtured through R&D funding. The government should initiate a systematic program to purchase energy-efficient equipment for its buildings, and energy-efficient vehicles for its fleets.
- The roles of DOE and the national laboratories in conservation R&D should be reviewed, clearly articulated, and communicated to industry. Many firms indicated they do not have a clear understanding of DOE's program goals or current R&D activities. DOE should work more closely with industry and the labs to determine the scope and direction of R&D, and to ensure that the results of the labs' R&D are transferred to industry.

INTRODUCTION

The U.S. Department of Energy's conservation R&D (research and development) programs fund R&D projects conducted by private industry, DOE's national laboratories, and universities. The programs principally support long-term, high-risk activities that might otherwise not be conducted by private industry, such as basic research, laboratory bench-scale tests, and the development of proof-of-concept prototypes. Four offices administer the programs:

- **Buildings and Community Systems** -- Conducts research, development, and technology transfer projects to improve building equipment, building envelopes, indoor air quality, lighting, design, construction, and retrofit practices, and community energy systems. FY 1989 funding: \$32.7 million.
- **Transportation Systems** -- Researches advanced automotive propulsion systems, electric vehicles, and alternative fuels, and develops advanced ceramics to provide components for high temperature engines and corrosive environments. FY 1989 funding: \$54.6 million.
- **Industrial Programs** -- Works with industry to design and develop cost-shared projects on improvement of energy efficiency in several industries, including steel, aluminum, textiles, paper, and chemicals. Researches recovery of energy in industrial waste streams and materials, and develops innovative cogeneration systems. FY 1989 funding: \$30.4 million.
- **Energy Utilization Research** -- Conducts cross-cutting basic research to support other conservation offices and the private sector. Research areas include combustion, thermal sciences, materials, catalysis, biocatalysis, and tribology. Also evaluates energy-related inventions. FY 1989 funding: \$30.9 million.

Since 1981, the conservation R&D programs have emphasized support for the early phases of the R&D process, with decreasing emphasis on the demonstration of new technologies.

SURVEY DESCRIPTION

In December 1988, the Alliance to Save Energy undertook an effort to solicit opinions about the role of the federal

government in conservation R&D. Senator Timothy E. Wirth, the Alliance's chairman, sent a cover letter and a set of nine questions (reproduced in the Appendix) to 89 senior executives in organizations that have participated in, or have direct knowledge of, DOE's R&D programs. The vast majority of the persons contacted were in private companies that have received R&D funding from DOE. Also represented were industry-funded research organizations and trade and professional associations.

Responses were received from persons in 31 organizations. Most heavily represented were companies and industry-funded research organizations that have participated in R&D projects funded by Buildings and Community Systems; these accounted for approximately half of the responses. Also heavily represented were companies engaged in advanced ceramics work funded by Transportation Systems. Fewer responses were received from organizations engaged in industrial or energy utilization research. Several companies have received funding from more than one DOE office. Within their organizations, most respondents were at the vice president level or higher.

Because we posed a series of open-ended questions, rather than "yes-no" or multiple choice questions as are typical of formal surveys, the responses varied greatly in length and structure. While a few persons wrote brief letters that touched on only some of the questions, the majority of responses included several pages of detailed answers to each of the nine questions. Additional perspectives were gained through meetings and phone conversations.

In the following pages we summarize the responses to each of the nine questions, attempting in each case to indicate where the weight of opinion lies. The final section presents overall conclusions. We do not attempt a statistical analysis of the results, due to both the non-randomized nature of the sample and the variations in types of responses. Direct quotations are used extensively throughout our report to convey the flavor of responses. While no respondents requested anonymity, we have chosen not to disclose their identities or affiliations in the belief that this would best foster continuing discussion and constructive criticism of DOE's R&D programs.

SUMMARY OF RESPONSES TO QUESTIONS

1. Are the federal programs adequately coordinated with private industry R&D initiatives? If not, how can they be better coordinated?

This question provoked the sharpest differences in responses among all questions asked. Only a handful of organizations responded with an unqualified "yes." Several others felt that coordination is usually adequate -- and, in many cases, improving -- but there is room for improvement. Roughly half of the respondents answered "no." In general, industry seeks a greater role in influencing the scope and direction of government-funded R&D.

The responses to the first part of this question are highly correlated with the size of the responding organization. All of the companies that felt coordination is wholly or usually adequate are large companies (or organizations supported by large companies). On the other hand, the majority of companies critical of coordination are smaller companies. Most of these companies are involved in building-related technologies. A frequent comment was that little information reaches these companies on R&D programs and developments.

Of the organizations that spoke well of coordination with industry, a few cited improvement in this area over the past five years. For example:

"Cooperation has existed for many years on the technical staff in several areas. More recently, DOE management on all levels have effectively broadened it through their active support of private-sector coordination."

More typical of the responses is this request for greater attention to industry's priorities:

"Private industry must play a bigger role in setting and directing federal programs. Private industry is more 'in touch' with the marketplace and the ultimate consumers. Private industry knows which energy efficiency technologies will face 'hard sell' and which will need federal support to achieve a successful market introduction."

A few responses referred to misunderstandings concerning the most appropriate roles for government and industry. For example:

"The basic problem is that the bureaucrats do not understand that industry R&D is conducted solely to

meet economic objectives whereas the government has a much broader strategic interest in dealing with global socio-political issues."

Several comments specifically addressed the role of the national laboratories. Some respondents felt the labs' role has not been articulated:

"Judgments should be made concerning which national laboratories should be in the energy development business, what they have to offer that industry can't provide, what their specific roles should be, and when they should stop their execution and transition programs to industry. National laboratories get a bad name from industry when their roles and interests substantially overlap."

Another company pointed to a need for better information on the labs' activities, as well as consideration of possible overlaps:

"An area where coordination can be improved are activities at the national laboratories. There is excellent basic research being performed there, but many industrial people are not aware of such activities. It is often necessary to contact all of the laboratories to determine the status of particular activities. In some cases it appears there is duplication of effort among laboratories. For example, in superconductivity . . . all nine of the national laboratories have some on-going effort."

Suggestions for improving coordination generally focused on expanding existing coordinating mechanisms to cover the full range of R&D areas:

"The best coordinated programs make use of industry advisory groups, provide for program reviews by groups of industry leaders, and require industry participation in every major R&D project."

Another suggestion was for greater industry involvement at the early stages of determining project priorities:

"The question which industry always asks, and government sometimes fails to, is: Is this a wise use of funds? Perhaps asking industry to evaluate the value of the project would be even more valuable than having industry provide direction for the R&D efforts."

2. Does private industry coordinate among itself its R&D adequately or are competitive concerns, antitrust issues, or other factors preventing it?

By a large majority, respondents said that industry does not coordinate well among itself. Both antitrust and competitive reasons were frequently cited. But several firms said that efforts at coordination are increasing.

While most respondents seemed to favor more extensive intra-industry coordination, a few indicated their preference for the status quo:

"Competitive concerns are an obstacle to private industry coordination. However, this competition is healthy and should not be tampered with."

Several respondents reported that coordination is increasing, especially through the establishment of R&D consortia. The Cooperative R&D Act of 1984 was cited as "paving the way" for increased cooperation. The favorable attitude of the Reagan administration toward consortia as a means of strengthening international competitiveness was also mentioned by several respondents.

Two respondents noted that coordination is especially difficult for companies at the leading edge of innovation. For example:

"Private industry in the main cannot coordinate among itself until products get old enough in their life cycle that trade associations can be established. . . . New entrepreneurial companies are rarely in a position to create or even join such associations."

The Gas Research Institute (GRI) was mentioned in several responses as a model of successful intra-industry cooperation.

3. How would you define the areas where the federal government should conduct R&D as opposed to private industry?

There is broad consensus that government should fund basic research and development of generic technologies that are high risk and have low probability of near-term payoff. Several respondents also emphasized government's role in responding to social issues, such as environmental protection and energy security. Many respondents stressed that the government should expand its demonstration and commercialization activities to help get the results of R&D into the marketplace.

Respondents used a variety of terms to describe the types of R&D work government should undertake. "Basic," "high-risk, high pay-off," "long-term," "generic," and "pre-competitive" were terms frequently used. These characterizations are consistent with DOE's own view of its role:

"The federal role in R&D focuses on the earlier phases of the process. [DOE] is willing to undertake precommercial states of 'higher risk' projects that show potential for large long-term benefits, but which would not be cost-effective for private organizations."¹

But many respondents envision a larger governmental role. Several state that the public benefits of energy efficiency R&D -- such as improved environmental protection and energy security -- justify government funding to push R&D efforts beyond what would be accomplished by market forces alone:

"I strongly support the concept that government funding is needed in basic research and generic technology development, but do not agree that this is the only role for government in energy R&D. While my experience leads me to support the notion that business and economic decisions can best be made by the private sector, I do not find that social and public decisions can best be made this way. . . . No one questions this philosophy when it comes to defense; we do not ask individual companies to invest to defend themselves from hostile nations. I believe that energy clearly falls into this same class. Are the long-term economic costs of dependence on foreign oil, environmental emissions, system reliability or even least-cost energy to the public accounted for in the decisions made by private industry? The record shows that they are not."

In a similar vein, another respondent said:

"Private-sector organizations are driven by short-term goals for profits and survival, and they are generally unable to shoulder the major costs and risks associated with major changes in procedures, processes and/or products simply because of an energy efficiency objective. Sharing these costs and risks is crucial if energy R&D is to result in outcomes beneficial to society, and it should be considered a key role and responsibility of the federal sector."

Several respondents suggested greater federal funding of "downstream" activities that support the demonstration and

¹U.S. Department of Energy, Energy Conservation Multi-Year Plan, 1990-1994 (August 1988), p. 1-5.

commercialization of the products of R&D, as seen in these examples:

"Presently federal R&D funds are often cut off too soon, before key questions regarding the technical and economic viability of a product have been answered through extensive testing under actual usage conditions."

"[A] helpful structural change would be to carry promising developments through the field-testing stage. In most cases, federal programs are dropped when the basic feasibility has been proven. As a result, many developments never make it to the marketplace. Supporting these programs further downstream would be of tremendous benefit in catalyzing commercialization."

"In the development of a new technology or product there is a continuum of activity: basic research, applied research, laboratory model, proof-of-concept unit, field test units, pilot production and full scale production. . . . The technical risk is reduced as one goes from step to step but the economic investment increases in each progressive step. . . . There is often a funding gap between the feasibility development and product development. The government can assist by joint funding [to close] this gap."

Further suggestions along these lines were provided in response to Questions 7 and 9, discussed below.

4. Are the current programs structured so that you can take maximum advantage of them? Are the cost sharing provisions, patent rights, or any other issues preventing you from participating in federal programs?

Most respondents felt that the structure of DOE's R&D programs does not inhibit their participation, but that improvements could be made. Patent rights, cost-sharing policies, and continuity of funding cause difficulties for some companies.

Several organizations said that contracting requirements and procedures are burdensome, but not an insurmountable barrier. For instance:

"The structure of the programs we are most interested in does not discourage our participation. [We have been able to work out] acceptable relationships with government sponsors."

This response is not surprising, since most of the organizations surveyed are current or recent beneficiaries of DOE funding.

A few companies elaborated on difficulties with DOE's patent rights policies:

"There is no question in [our company's] opinion of the archaic, unwieldy, and non-productive patent rights position of the DOE; it must be changed. The DOE alone among federal agencies attempts to retain patent rights rather than allow retention by the contractor. The contractor must undergo a lengthy and expensive process to convince the DOE to 'waive' its 'rights.' . . . Perhaps the DOE's patent rights philosophy is the most negative factor in encouraging greater participation in Department programs by the private sector."

Several respondents indicated that current cost-sharing requirements can be burdensome, particularly for smaller companies with modest financial resources. Also, it was suggested that the level of cost-sharing required should be made more flexible to account for the risks involved:

"On some of the more technically aggressive, high-risk but higher-payoff technologies, it would be re-appropriate to re-examine the cost share requirements since these can inhibit industry participation."

A third problem, in some instances, has been continuity of funding:

"While cost sharing provisions have been fair, [our company] has on several occasions borne all costs for long periods to 'keep the work alive' while DOE sought sufficient funding from OMB to contribute the federal share on a sustained, multi-year effort."

5. Have you participated in or benefited from federal R&D? Have you been actively involved in supporting the program? If yes, how? If not, why not?

As would be expected from the survey sample, most respondents reported that their organizations had benefited from federal R&D, generally as a recipient of current or recent funding. A few reported an indirect impact:

"Our company has been extremely successful commercializing and exploiting [energy conserving products based on] . . . a technology which, though not developed with federal dollars, was nurtured by them in its formative period about ten years ago. In many

respects our company has had an indirect impact from programs previously sponsored by DOE."

Several organizations said they have actively supported DOE's R&D programs in various ways, including: presenting Congressional testimony; informally advising DOE; serving on program planning and evaluation panels; and providing researchers with materials at no cost.

6. What is the one specific highest priority area or technology where the federal government should be increasing its R&D? Why? You can include one technology from your own firm or industry, but please also include one from another area as well.

Many different technologies were cited in response to this question; some respondents listed several. No single response dominated the answers, but the following energy efficiency-related research areas and technologies were mentioned in three or more responses:

- Motors vehicles, including electric vehicles
- Ceramics
- Mass transit
- Heat pumps
- Cogeneration
- Non-chlorofluorocarbon refrigerants
- Superconductors

Additionally, many respondents suggested areas that are outside the scope of DOE's conservation programs. Solar, renewable, and nuclear technologies -- especially research on passively-safe nuclear reactors -- each received several mentions.

7. Why are new technologies that are being developed penetrating the market fairly slowly -- assuming, even with today's low energy prices, they are cost effective? How can we increase the rate of penetration of new technologies?

Most respondents blame the slow market penetration of efficiency technologies on a cultural tendency in the U.S. to require short-term profit and payback. Industry's failure to relate R&D results to marketplace needs is also cited. Suggestions for addressing this problem include more emphasis on commercialization in DOE's R&D programs, federal

purchases of energy-efficiency technologies, and legislative approaches such as taxes and standards.

Many respondents spoke of a pervasive tendency to focus on short-term results and require quick recovery of investments. For instance:

"Paybacks of three to four years, acceptable in most Japanese and European businesses, do not meet investment guidelines for U.S. companies, a regrettably shortsighted situation."

Another company cited its frustrating experience with an advanced industrial heat recovery device that has been proven in commercial operation to cut process gas consumption 35 percent, but has still not been embraced by the target industry -- despite a two-year payback.

Successful commercialization is also hindered by marketing problems that were not anticipated in the research stage, as suggested by the following remarks:

"Development is often done in isolation from the ultimate producer or user of the product. . . . The manufacturer must often start from scratch to develop the product using the new technology. The time required for this sequential approach could be greatly reduced with some form of parallel effort."

"New technologies are often . . . not taken far enough in the development cycle for industry to implement them in competition with existing technology. An understanding of how much development is enough can only be gained through intimate working relationships with leaders of the implementing industry. These relationships are rarely established as part of the R&D process, but they are necessary for efficient commercialization."

Most of the proposed solutions to poor market penetration emphasize a larger federal role in the latter stages of development and commercialization (as discussed above under Question 3). For example:

"The slow pace of introducing new technologies into the marketplace is largely due to the huge gap that still exists between the stages of proven technological feasibility and proven economic feasibility. The closure of this gap requires much more focus on advanced development, prototyping, and demonstration programs."

A specific approach suggested by six different respondents is for the federal government to "lead by example,"

committing to purchase cost-effective energy efficiency technologies for its buildings and vehicle fleets:

"The federal government -- the largest buyer of goods and services in the world -- does not create the markets necessary to introduce new technology."

"Market development could be encouraged by large-scale use of new products at government facilities, such as laboratories, post offices, and military bases. Such use would create the initial market for the product, assist the enterprise through the critical start-up period, and boost the confidence of consumers."

Another suggestion was for legislation to mandate the use of certain technologies that provide clear life-cycle cost savings. Federal legislation enacted in 1988 that established minimum efficiency standards for fluorescent lighting ballasts is a model for this approach.

Several respondents recommended amending the tax code to encourage venture capital funding of energy innovations and to provide incentives to users of energy-efficient products.

One respondent stated that a tax on energy consumption would be the single most effective policy:

"It is certainly heresy for me to say this, but I am now convinced that it is time to tax energy consumption and to get rid of most of our DOE-developed energy conservation programs. With the proper incentive, conservation will happen. I believe that it has been significantly demonstrated in the past, and cheap energy today is dampening the creativity and demand for energy conserving products and practices."

8. Why are many of the technologies invented here being commercially produced only overseas?

"Higher overseas energy prices" was the most prevalent answer to this question. Other factors cited include foreign companies' comparative advantage in production technologies, a greater willingness to assume risks, and governmental assistance.

A few respondents took issue with the premise of this question; two said specifically that it does not apply to the lighting industry. But most pointed to higher energy prices overseas, which justify greater investments in conservation technologies.

Several respondents explained that foreign companies are more risk-oriented than U.S. companies. The differing

attitudes toward risk are believed to be partly attributable to government policies:

"Foreign -- especially Japanese and European -- corporations tend to follow strategies that involve R&D investment in technologies with significant short-term risk, modest or low near-term ROI [return on investment], but good longer-term economic potential. These differences reflect a 'cultural' difference in business philosophy from that prevalent in the U.S. And they are fostered by the governments of these countries through a variety of cost/risk sharing incentives and programs, frequently with the objective of capturing foreign markets critical to their export-oriented economics."

Other respondents noted that foreign companies often have lower-cost labor and are more skilled in production technologies:

"Overseas producers are often more effective in teaming development and production people, and are almost always focused on technology of production, rather than on innovation."

9. In addition to just R&D, should the federal government begin a new initiative -- cost-shared with industry -- of demonstration of new technologies? Would it be effective to structure it so that the pool of federal money for demonstration is given out in response to a Request for Proposals (RFP)?

Most respondents strongly favored more government-funded demonstrations of energy efficiency technologies. Companies expect to cost-share, but on flexible terms, possibly including pay-back of assistance out of eventual profits. RFPs are seen as a fair vehicle for allocating assistance, but several respondents suggested that more flexible procurement strategies also be used.

Enthusiasm for more demonstration projects is clear in many responses, some of which were discussed above in relation to previous questions. A typical response:

"Yes, realistic, market-based, user-hands-on demonstrations of new technologies are a must for insuring commercialization and thus payback for the taxpayers' investment."

Some respondents emphasized that demonstrations alone are not sufficient -- they must be coordinated with other commercialization efforts:

"Federal demonstration projects have stumbled in the past because most funds were spent on the demonstration and little on examining the results and less still on getting the findings out to those who could put them to use."

Cost-sharing is favored, but (as in the answers to Question 4) companies hope that it could be done in ways that would not discourage participation or discriminate against smaller firms. Some respondents suggested that companies' cost-share obligations be fulfilled by offering the government an equity position or royalties on eventual sales. A few persons suggested that the amount of the cost-share should be determined on a case-by-case basis. For example:

"The industry cost share should be on a 'sliding scale' to adjust its level to be indicative of the technology maturity in the demonstration; the nearer the technology is to commercialization, the higher the industry cost share should be."

Most respondents favor use of RFPs; but some noted the potential to inhibit firms' creativity:

"Care must be taken to avoid RFPs that over-specify and give 'how to' requirements rather than 'what' type goals and objectives. It is important to recognize that the nature of R&D contracts requires the assumption of risk on both sides and 'commitments' are best stated as goals in order to encourage the proposal of high pay-off technologies."

In a similar vein, other respondents suggested that at least some of the demonstration portion of funds be allocated through unsolicited proposals:

"Funding should also be available to support unique ideas submitted in the form of unsolicited proposals. The potential stream of good ideas should not be jeopardized by procurement procedures that insist on 'going competitive' for development of ideas brought to a federal sponsor."

"A better approach [than RFPs] is to provide the demonstration funding to the enterprise which has developed the technology/product and which is strongly interested in 'championing' the product into the marketplace."

CONCLUSIONS AND RECOMMENDATIONS

By and large, the industry leaders surveyed by the Alliance are strongly supportive of DOE's conservation R&D programs.

Running through their responses are three themes regarding possible improvements. We restate these themes here in the form of recommendations:

- DOE should expand its support of demonstration projects and other commercialization activities. Some new energy efficiency technologies that have been funded through the proof-of-concept stage never make it to market because of the high costs and risks of commercialization. In some cases, these concepts are picked up and commercialized by overseas competitors. Since 1981, DOE's conservation R&D efforts have been concentrated on long-term, basic research on generic technologies; funding for specific products and demonstration-oriented activities has diminished. As a result, the U.S. lags in getting new energy-efficiency technologies into production.

DOE can address these problems by providing strong and stable funding for demonstration and commercialization activities. While industry should be expected to contribute financially to these projects, the cost-sharing requirements should be eased for smaller firms -- perhaps through a mechanism that would recapture the government's investment after a product is successfully commercialized.

Demonstration and commercialization funds can be allocated through a Request for Proposals (RFP) process, but a portion of the funding should be reserved for unsolicited proposals.

- The federal government should help create a market for energy efficiency technologies through a purchasing program. The government is a massive consumer of energy-related technology, but does not use its purchasing power to assist in the market development of efficiency innovations that have been nurtured through R&D funding. The government should initiate a systematic program to purchase energy-efficient equipment for its buildings, and energy-efficient vehicles for its fleets.
- The roles of DOE and the national laboratories in conservation R&D should be reviewed, clearly articulated, and communicated to industry. Many firms indicated they do not have a clear understanding of DOE's program goals or current R&D activities. The process by which broad goals are translated into program and funding priorities is unclear. Differences between societal goals --

such as national security and environmental protection -- and the private sector's goals must be recognized in program design. DOE should work more closely with industry and the labs to determine the scope and direction of R&D, and to ensure that the results of the labs' R&D are transferred to industry.

**The
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To Save Energy

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APPENDIX



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Harvard Business School

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Labor Union of Energy Employees

Edward E. Wirth
Chairman of the Board
North Atlantic Treaty Organization
Foundation

Stephen Wolf
Chairman, Energy Conservation Committee
National Association of Manufacturers
Commissioners

James L. Wolf
Executive Director

December 9, 1988

Dear _____:

I am writing to solicit your opinions about the federal role in R&D and demonstration programs for energy efficient technologies. I want to work to ensure that federal programs in these areas reach maximum effectiveness. I also want your opinions on what new initiatives are needed, and how to structure them.

Both as Chairman of the Alliance to Save Energy and as a member of the Senate Energy Committee in the Congress, it is apparent to me that energy efficiency must assume an even larger role in our energy future. From global warming to affordable housing, energy efficiency is one of the most effective strategies to deal with many of our pressing national problems. Because of concerns about the deficit, however, the base federal program as well as any new initiatives must be carefully evaluated and actively supported by a broad coalition of industry and energy efficiency advocates.

I have enclosed a set of questions about this topic for your review. I hope you will give me your thoughts and comments in writing. I am also sending this letter to a select group of other industry leaders. Do you think it would be valuable for me to convene this group in Washington to discuss these issues sometime this winter? We would structure the meeting so we could coordinate your visit with other members of Congress or their staff.

Thank you for taking the time to respond on this important issue. If you have any questions, please do not hesitate to contact me or James Wolf, Executive Director of the Alliance to Save Energy.

With best wishes,

Sincerely yours,

Timothy E. Wirth
United States Senator

THE ALLIANCE TO SAVE ENERGY
SURVEY QUESTIONS ON DOE'S ENERGY CONSERVATION R&D PROGRAMS

1. Are the federal programs adequately coordinated with private industry R&D initiatives? If not, how can they be better coordinated?
2. Does private industry coordinate among itself its R&D adequately or are competitive concerns, antitrust issues, or other factors preventing it?
3. How would you define the areas where the federal government should conduct R&D as opposed to private industry?
4. Are the current programs structured so that you can take maximum advantage of them? Are the cost sharing provisions, patent rights, or any other issues preventing you from participating in federal programs?
5. Have you participated in or benefited from federal R&D? Have you been actively involved in supporting the program? If yes, how? If not, why not?
6. What is the one specific highest priority area or technology where the federal government should be increasing its R&D? Why? You can include one technology from your own firm or industry, but please also include one from another area as well.
7. Why are new technologies that are being developed penetrating the market fairly slowly -- assuming, even with today's low energy prices, they are cost effective? How can we increase the rate of penetration of new technologies?
8. Why are many of the technologies invented here being commercially produced only overseas?
9. In addition to just R&D, should the federal government begin a new initiative -- cost-shared with industry -- of demonstration of new technologies? Would it be effective to structure it so that the pool of federal money for demonstration is given out in response to a Request for Proposals (RFP)?

Senator WIRTH. Thank you, Mr. Wolf.
Finally, Mr. Sklar.

**STATEMENT OF DR. SCOTT SKLAR, EXECUTIVE DIRECTOR,
SOLAR ENERGY INDUSTRIES ASSOCIATION**

Dr. SKLAR. Thank you, Senator Wirth.

The Solar Energy Industries Association is the trade association for both the photovoltaic and solar thermal manufacturers and component suppliers. We obviously enthusiastically support the bill.

Each of our industrialized competitor nations, every single one, is spending more on solar renewable energy and energy conservation. There isn't one. They are all moving forward. We are moving backward on the solar side of life, and it is really due to a microcosm of how the United States deals with high technology. We sort of have a gap in how we develop and R&D program and how we commercialize those technologies and bring them to the marketplace.

The industry deserves a lot of praise in both the conservation arena, the solar and renewable energy for still being able to commercialize technology when both the messages from government have not always been clear. Energy prices have dropped precipitously, and somehow the American public and the Congress haven't been able to get it together to promote these technologies. And I think this bill will serve as a beacon to how we can address it. We thank you.

We were hoping when President Bush took office with his words on supporting the environment, that would result in a change in terms of how they approach the budget. The 30 percent cut request of photovoltaics is an example that they are going on with business as usual, where we are outspent two to one by Germany in photovoltaic research starting last year because that country sees that there are multi-billion dollar markets throughout the world.

And, obviously, we are surpassed by Japan in photovoltaic R&D. It is an example of how our international competitors are going to take all these technologies, and it is not just photovoltaics, but many of the technologies that Professor Rosenfeld has demonstrated, and not be sleazy, but in fact just take advantage of the marketplace and run with it.

We have to be smart and not necessarily rely on technologies of the past. I hope that in the years to come, most of the energy jobs in Colorado, West Virginia and others will be provided by solar and renewable and energy conservation industries. And, in fact, per Btu we provide more jobs than any fossil fuel.

There have been some major benefits of these programs, one of which I would like to point out in solar thermal power. We have in January 1989 marked a breakthrough and have 200 megawatts on line of private sector financed power. That will become 500 megawatts in a few years. The sole reason that has happened is that the R&D program has worked. It has brought technology to the marketplace, made it less expensive.

The regulatory environment has been a prime mover. There has been PURPA to relate interconnection of the grid. There has been

a 10 percent tax credit for commercial applications still kept in place.

And most of all, the environmental climate is that it is the only kind of peak power plant that you can put up and construct in less than a year. It takes that long for just a basic regulatory approval of natural gas or fossil fuel plants. We have some capability that other plants don't.

The new technologies, the second generations of solar thermal, will not only bring down these plant costs below 12 cents a kilowatt hour, but in fact is now being used to use solar concentration to break down toxic waste at Sandia National Labs. And we can see that there may be very low cost ways to break down toxic waste using photochemical flux.

Photovoltaic technology has also improved. Through work both at SERI and Sandia and the industry, we have broken 20 world records as of January 1989 with photovoltaic technology.

Thin films is in the marketplace. I brought my toys too. And here is a 3 watt, thin-film battery charger made in the United States, and it is absolutely flexible. And we are seeing sales now in thin-film technology pass the \$60 million a year phase, all out of the Federal research effort.

Finally, if you didn't miss the point, buildings are 35 percent of our energy use, and if we don't make some moves both in energy conservation, use of passive solar technology in building design and solar hot water heating, we are crazy. There is no absolute reason why we shouldn't. And as I have said before in front of this committee, the United States by January 9 has surpassed the 1.2 million mark in using solar water heaters for homes across the United States. In Japan, the City of Tokyo has 1 million solar hot water heaters. And the fact of the matter is they are committed to commercialize and utilize this technology.

My basic conclusions are we have to knock the bias out of R&D. And I brought the chart, and it is in my testimony. But you can see very clearly that the conventional energy resources in this country have basically received a consistent support of R&D. And you can see that renewable one there slanting downward and almost to the point that it is not being useful anymore. We have to change that slant at least to level. And I hope that the theme in your legislation to not only maintain it, but increase it goes a long way and is heard here.

In addition to increased Federal R&D, we need enhanced export assistance. Sixty-five percent of our sales are overseas. And, in fact, half the world's population doesn't have access to a light bulb. And the fact is that solar, both thermal, photovoltaics, the other renewables, such as wind and biofuels, can make an absolute impact on the quality of life in this world. And particularly tied to those low voltage bulbs, we can go a long way.

We also have to be concerned that India and the People's Republic of China will be turning toward coal if we do not figure out some way to ensure that they have access to this technology. And those two countries with massive populations going to coal will have a profound impact on global climate change.

Third, we need regulatory flexibility. We need to be able to show that not only can you use energy conservation, which is a great

idea, but you can use solar renewable technology to meet EPA-mandated emissions limits. That needs to be done fairly quickly.

We also need to make capital available to utility companies to use new technologies, make them take a risk. It is much more evident in conservation right now, and they need a kick just to go in that direction. But I think for the production technologies and renewables, we need to figure a low-cost way of capital to them.

We also need to get rid of our fixation of dealing with base-load plants. The biggest impact we can have in utility production after conservation is to change their method of production to supplant peak power plants. They are the oldest. They are the most costly form of power. They are the most polluting, and those are the plants that are going to be changed first. And right now many applications of solar renewable technologies can cost-effectively replace it without any problem if there was capital and using the bully pulpit of the presidency to push it.

Finally, in our international approach, we need to figure out ways in which we can bundle these technologies through the World Bank and development banks so that we can finance them intelligently. We also need to educate bankers, both private sector and their technical advisers, to all these kinds of technologies, and the government has to be the major partner because if we do not educate them, it is my view that the U.S. market will not be strong. Our international competitors will lead in the production of the technology at home, and then when we are ready, we will be importing all this from overseas for no good reason.

Thank you for introducing the bill.

[The prepared statement of Dr. Sklar follows:]



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TESTIMONY

by

SCOTT SKLAR
EXECUTIVE DIRECTOR
SOLAR ENERGY INDUSTRIES ASSOCIATION

before

SENATE ENERGY & NATURAL RESOURCES COMMITTEE

on

NATIONAL ENERGY POLICY ACT OF 1989

MARCH 14, 1989
WASHINGTON, D.C.



INTRODUCTION

I am pleased to have the opportunity to testify in support of the National Energy Policy Act of 1989 (S.324) which provides multiyear authorizations for solar research & development, joint venture support, federal procurement incentives, and export assistance. This legislation is critically important to the U.S. solar industry and will expand solar usage which will directly offset the use of fossil fuels thus slowing global climate change.

The United States is facing a crises that may very well determine our place as a world economic power in the 1990's. Although we possess great technical creativity, we seem unable to commercialize our discoveries in the marketplace and as a result, we have seen our international competitors commercialize our creations and reap the billions of dollars and millions of jobs from these endeavors.

The American people are about to witness a replay of this sorry state of affairs in our handling of the federal solar research and development programs. Virtually every industrialized country has increased their federal R&D in solar energy technology. The German and Japanese governments surpassed U.S. photovoltaics R&D for the first time in 1988. The Spanish and Swedish governments may surpass U.S. solar thermal power R&D in 1988. The Danish and Swiss governments will approach U.S. solar buildings R&D in 1989.

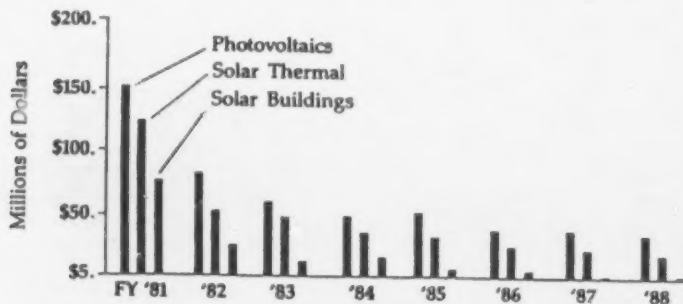
The new Administration has requested a 30 percent cut for photovoltaics research from \$35.5 million in FY'89 to \$25.0 million in FY'90, which has already been cut yearly from \$155.0 million since FY'81. The Administration also has proposed cuts of 15 percent for solar thermal power research from \$15 million in FY'89 to \$13 million in FY'90 which has been cut yearly from \$121 million since FY'81. The Administration has recommended a 20 percent cut in the solar buildings research program from \$5.4 million in FY'89 to \$4.2 million in FY'90 which has been cut yearly from \$77 million since FY'81.

Why in the face of increased international competition and major concerns about global climate change is the United States essentially closing down its federal solar research programs? Why have the solar programs sustained far greater cuts than other federal energy research & development programs? Why would the United States slash research programs at a time when these technologies are becoming cost-competitive in the marketplace?

The years of 1989/1990 will determine whether the United States will have a domestic solar energy industry or relinquish its technological leadership to our international competitors. Our country faces the real possibility of importing solar technologies in the years when they become fully cost-competitive. From my point-of-view, the United States lacks an effective energy policy and has biased priorities against maintaining our technical predominance and development of solar and renewable energy technologies. This bias is exemplified by the Administration's request to cut the \$352 civilian nuclear energy research budget by only \$2 million in FY'90 in contrast to their request to cut the aggregated solar budgets of \$56.9 million by \$13.2 million.

At some point, the U.S. Congress must come to terms as to whether you want to maintain a United States solar energy research effort. The U.S. Congress must also come to terms that at some level, lower solar budgets will not be effective in furthering the technology. The Solar Energy Industries Association, the national trade organization of the photovoltaic and solar thermal manufacturers & component suppliers, believes that the FY'89 funding levels are that bottom line. Therefore, the U.S. solar energy industry asks this Committee to hold the line, maintain an effective U.S. solar energy effort, and come to grips with the reality that if the United States does not push the technology out of the research pipeline, our international competitors will, and the United States will be totally reliant on our competitors for solar technologies for generations to come. Congressional actions in these two years will determine the outcome since the Administration has shown a "business as usual" approach.

Trends in Federal Solar R&D FY '81 - FY '88



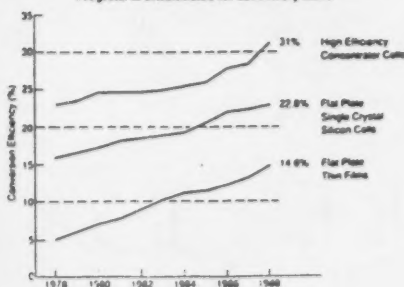
PHOTOVOLTAICS

The United States photovoltaics program has three basic thrusts: Bring down the costs of the technology through increased efficiency through the development of new materials and processes in manufacturing photovoltaic cells; Assist the industry in cost-shared research to commercialize research developments; and provide design assistance & review for large-scale photovoltaic systems for export, and government & utility procurement.

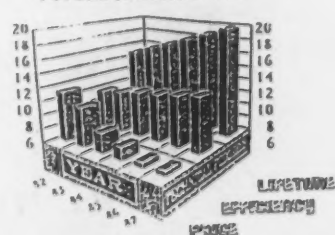
As you can see in the addenda, the photovoltaics program has made great strides with over twenty world efficiency records of photovoltaic cells and modules. The chart below summarizes the cost reductions and the increases in lifetime & efficiency over the last six years as a result of the research program. The United States has maintained our technological lead worldwide due directly these research efforts. However, while the U.S. photovoltaic marketshare has been maintained through level funding during the FY'88-89 years, the precipitous cuts recommended by the White House (30%) will undercut the U.S. industry so badly that it is very unlikely the industry would ever recover. I cannot emphasize enough to this Subcommittee, that whatever the Congress decides has profound effect on the private investment markets. When Congress maintained level photovoltaic research monies in FY'89, increased private capital flowed to our industry. If Congress cuts this small research program, the private markets will sense that the United States government lacks the resolve to commercialize photovoltaic technology, and disinvestment will occur. Program cuts will insure that the United States will lose both our technological and market leads to both Germany and Japan.

The U.S. Department of Energy Photovoltaic Program has been effectively managed, and has developed an excellent relationship with the private sector. The national laboratory and university efforts are effectively integrated into the research program. This R&D program is a model on how best to commercialize high-technology. Funding for FY'90 should be increased to \$40 million or at least maintained at the current \$35.5 million level.

Progress in Efficiencies for Laboratory Cells



PV POWER MODULE STATUS



SOLAR BUILDINGS

The U.S. Department of Energy Solar Buildings Program is the smallest of the research and development programs and has been essentially at a closedown level of \$5.4 million over the last few years. While buildings consume nearly 35 percent of U.S. energy and produce more greenhouse gases than the U.S. utility sector, this energy research area receives the least support. While the United States sits idly by, our international competitors in Scandinavia and Japan have geared up to commercialize energy efficiency technologies which have already begun to enter the United States market.

The solar building research effort has centered on three basic research areas: Solar cooling research using desiccant cooling technologies and new polymers in desiccants which can absorb up to 2000 percent of their own weight, efficiently dehumidify air thus providing cost-effective space cooling. The result of this research will save consumers millions of dollars for space cooling as well as saving utilities from building costly power plants to meet daytime cooling demands.

The second research area focusses on both passive and active solar design assistance. The Solar Energy Research Institute has worked with industry to develop a computerized energy simulation program for seven building types in two climate zones. This computer program will help builders select cost-effective passive solar applications in our nation's buildings. Under US/DOE auspices, SEIA and ASHRAE have developed a commercial-scale solar water heating design manual based on our experience over a decade with solar systems on federal and commercial buildings. In 1989, SEIA/DOE will develop and publish companion installation and operations/maintenance manuals for these large-scale systems. The final program thrust involves research on electrochromic or "smart" windows. By depositing a transparent metal-oxide material on glass, cooling costs for both buildings and automobiles may be significantly lowered. This technology along with photochromic glass has useful potential in the active solar industry in making collector glazings more efficient.

The potential markets for energy efficient technologies are extraordinary. But again, if the United States does not have the interest to commercialize these technologies, our competitors will. Does the United States have the resolve to follow-through on its research? Only the U.S. Congress can answer this question.

SOLAR THERMAL POWER

The United States now has 200 megawatts of completely private sector financed solar-steam-to-electricity utility-grade power plants. The solar trough concentrators used derive directly from US/DOE-sponsored research. This glass technology will soon be superceded by US/DOE developed stretched membrane technology utilizing a silver-coated polymer. The polymers will reduce the cost of this technology even further. Utilities are utilizing solar thermal technology for peak-power applications because they produce the most power during the utility's greatest demand for electricity (noontime), and they have minimal regulatory obstacles due to their cleanliness (no polluting emissions) and surety of supply (sunlight) that they can be constructed within fifteen months.

The U.S. Department of Energy Solar Thermal Power Program has three major program thrusts. First, the program will finish the upgrading of stretched membrane dishes and heliostats to efficiently concentrate sunlight. Actual trial tests are necessary to assess research progress and permit fine tuning. Secondly, second generation work to develop working solar dish concentrators which focus sunlight on engines that are capable of running electric generators, is being pursued through industry joint ventures. Finally, technology spin-offs to power lasers and detoxify wastes will be aggressively pursued as a new cost-effective high value market for these technologies.

The solar thermal technologies are also being commercialized by our industrial competitors. The European Consortium, Phoebus, plans to build a 30 megawatt solar central receiver tower in Jordon using stretched membrane heliostats. Such a venture by European governments may thrust European industries as the major commercializers worldwide of this technology.

The Solar Thermal Power Program should be funded at the \$20 million level in FY'90 to remain competitive. A minimum of \$17.5 million is necessary just to maintain ongoing programs. Cuts to \$13 million as proposed by the Administration would effectively cut out the U.S. industry from federal research efforts and just support limited laboratory work that may never be commercialized. Price breakthroughs, so far, have been very promising as shown in the charts in the addenda taken from the August 1988 Report to Congress titled, "Bringing Solar Thermal Technology to the Marketplace".

Page six

Solar thermal power technologies have shown that they are competitive in the peak power utility markets today. New advances in technology will make them even more competitive. The world markets offer a virtually unlimited opportunity to successfully commercialize these technologies. Solar thermal power offers a competitive way not only to produce electric power but detoxify hazardous wastes, accomplished successfully by Sandia National Laboratories in 1988. Successful experiments by the Solar Energy Research Institute in 1988 which concentrated sunlight 60,000 times, enough to power lasers, is a breakthrough important to pursue.

The Solar Thermal Power Program has an effective working relationship between the primary national laboratories, the Solar Energy Research Institute (SERI), Sandia National Laboratories, and the U.S. solar thermal industry. The research program deserves higher consideration by the Congress as an important element of federal research.

INTERNATIONAL

The international line item of the U.S. Department of Energy supports multiagency activities mandated under P.L. 97-370 which created the federal interagency board, The Committee on Renewable Energy Commerce and Trade (CORECT) to coordinate federal efforts to promote solar & renewable energy exports. This small \$1 million program leverages more money than any renewable energy program in the U.S. Department of Energy Conservation & Renewable Energy program.

Aside from a series of trade missions and education materials, the program is supporting a conference and trade show in May 1989 to promote U.S. renewable energy technology & services in the Caribbean Basin & Latin America. The program coordinated by the U.S. renewable energy trade association umbrella group, the U.S. Export Council for Renewable Energy (US/ECRE), is the first of a series of market sector promotion program geared to meet increasing international competition from our international competitors.

The \$1 million program should be increased to \$2.5 million rather than cut to \$0.5 million as recommended by the Administration. For the last eight years, the United States renewable energy effort was focussed, wrongly, on long-term, high risk, research & development. This small program is the only short term government effort to meet our competition head-on. The international program ought to be preserved and enhanced.

CONCLUSION

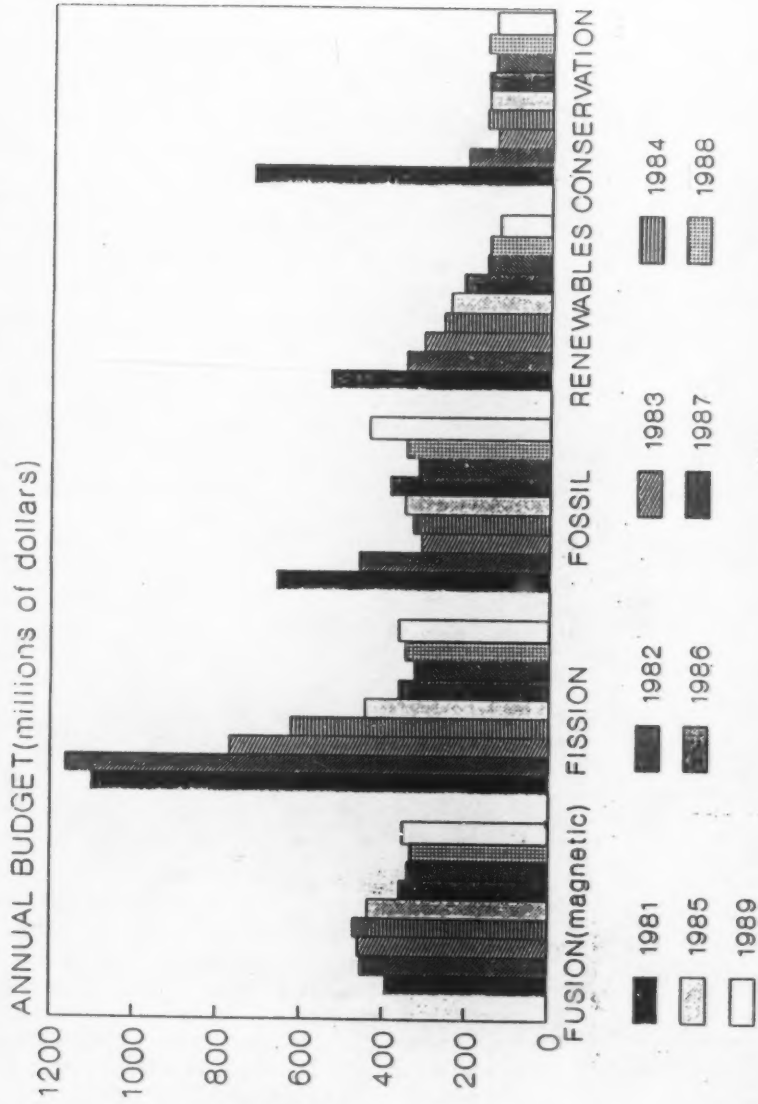
The United States has reached a time of reckoning regarding whether our nation is committed to realize its federal R&D investment over the last fifteen years, or relinquish our technological lead and the potential multibillion world markets for solar energy technologies. At minimum, the United States must restore the federal research effort. The legislative proposal to develop joint ventures with U.S. industry is an innovative way to spread the technology. Since our industry is undercapitalized, industry contributions should include land, in-kind labor, and state government contributions.

The \$24 million needed to effectively bring these technologies to the marketplace and maintain the United States' technological lead, can easily be pulled from ongoing U.S. Department of Energy civilian R&D programs. The provisions in S.324 which effectively doubles the international export assistance programs represents an aggressive policy to commercialize U.S. industries' R&D successes.

The legislation's drawbacks are twofold. First, it does not insert renewable energy applications in ongoing environmentally-mandated regulations that limit emissions of fossil fuels and sets mandated goals for regional air quality. A regulatory push for solar applications to offset fossil fuel combustion in contrast to technology approached designed to clean dirty fuels is preferable. Second, investment capital must be made available to solar project investment through ongoing federal loan programs and increased incentives to lure private capital and utility investment. New and novel approaches must be developed for large-scale use of solar & energy efficiency applications.

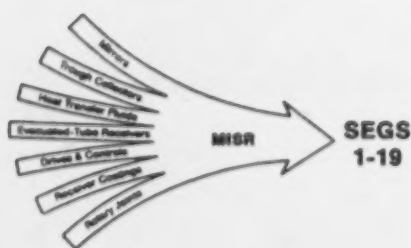
Hopefully, the Congress will reevaluate policies and funding of the solar research & development programs, and will seek to maintain the United States lead in this technology. Other initiatives to promote government/industry joint ventures, enhanced federal government procurement and export promotion represent bold steps to show the world that the United States will follow through with technology commercialization and market leadership. Passage of The National Energy Policy Act of 1989, S.324, will accomplish these goals.

ANNUAL APPROPRIATIONS OF DOE CIVILIAN R&D PROGRAMS (current dollars)

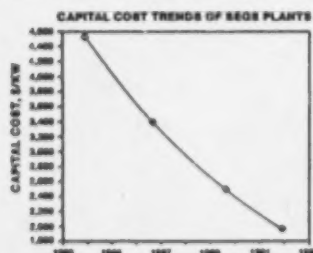


SOLAR THERMAL RESEARCH & DEVELOPMENT

As illustrated below, innovations in materials and components for parabolic troughs were integrated into and proven by the DOE Modular Industrial Solar Retrofit (MISR) systems. These enabling technologies encouraged Luz to employ these component improvements in its commercial systems. As innovations were incorporated into successive commercial systems, each new generation reflected lower system capital costs and lower energy production costs as illustrated. Luz is now considering further reductions in cost by replacing hybrid solar/gas steam generators with storage systems currently under development by DOE. Specific feedback of this kind is incorporated into the DOE research and development program and strengthens industry's ability to continue deployment of systems in broader applications with increased user confidence.



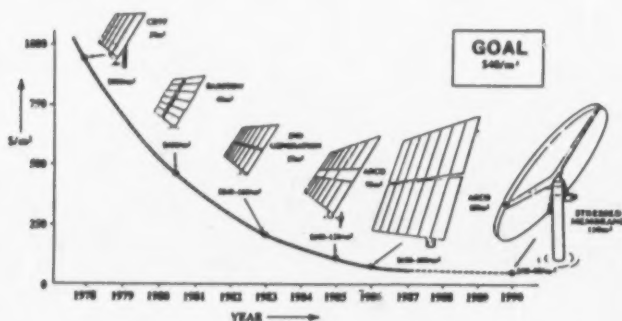
Commercial Solar Thermal Systems



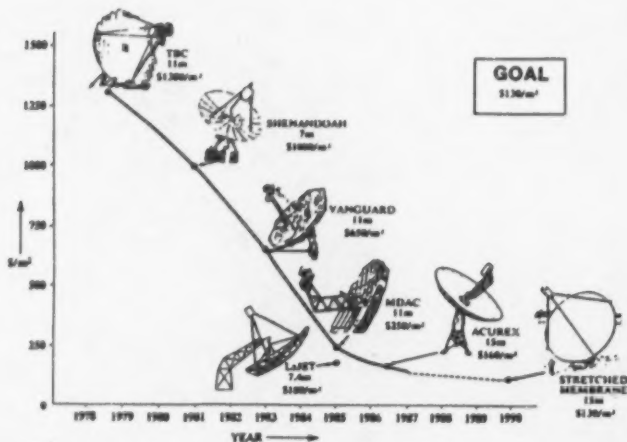
Such processes, in the longer term, also allow solar thermal systems to enter advanced applications such as hazardous waste destruction, materials processing and fuels and chemicals processing. While prototype solar thermal systems have not been tested in these applications, industrial manufacturers of concentrators have begun to see how the low-cost membrane dish concentrators and central receiver technology can directly be used to conduct chemical reactions in a receiver/reactor. Laboratory data have encouraged industry to begin to develop plans and assess the market potential for integrating solar thermal systems into these emerging applications which have national importance.

Receivers for solar thermal systems have also evolved during the past decade. Initially small-scale field experiments were needed to investigate the feasibility of using tube receivers to produce steam. In the early 1980s a scaled-up water/steam receiver was deployed in the 10-megawatt Solar One Pilot Plant, a systems experiment developed by DOE in conjunction with Southern California Edison Utility Company. Today's R&D efforts are aimed at further reducing receiver costs through the use of advanced designs and molten salts as the heat transfer fluid.

*Progress In
Heliostat R&D*



*Progress In Dish
Collector R&D*



Selected New Records Set by Program-Related Research During 1988

Achievement	Old Record	New Record	Who Set It
Conversion efficiency for a small a-Si three-junction cell (0.25 cm ²)	—	13.3%	Energy Conversion Devices
Conversion efficiency for a two-junction a-SiC/a-SiGe submodule (900 cm ²)	—	6.3%	Solarex
Conversion efficiency for a large single-junction a-Si module (2900 cm ²)	5.8%	6.7%	Chronar
Largest commercial thin-film a-Si modules (area in ft ² and power in watts)	7.6 ft ² 41 W	18.5 ft ² 45 W	Energy Conversion Devices
Conversion efficiency for a tandem a-Si cell on copper indium diselenide (2 cm ²)	—	14.6%	ARCO Solar
Conversion efficiency for copper indium diselenide submodule (936 cm ²)	6.5%	11.1%	ARCO Solar
Conversion efficiency for copper indium diselenide cell (1 cm ²)	12.9%	12.9%	ARCO Solar, Boeing
Conversion efficiency for small single-junction a-Si cell (0.25 cm ²)	10.6%	11.0%	Ametek
Conversion efficiency of a-SiC submodule (1.4 cm ²)	5.1%	6.1%	Photon Energy
Conversion efficiency of thin-film polycrystalline silicon (1 cm ²)	22.6%	24.2%	Astro Power
Conversion efficiency of small single-junction a-SiC cell (0.25 cm ²)	24.7%	24.7%	Spire Corp.
Conversion efficiency for small single-junction a-SiC cell (0.25 cm ²)	20.2%	22.4%	Kopin
Conversion efficiency for small 100X indium phosphide cell (0.25 cm ²)	17.5%	18.9%	SERI
Conversion efficiency of multi-cell concentrator combination (205X)	19%	24.6%	Varian Associates
Conversion efficiency of GaAs concentrator cell with prismatic cover (200X)	26.4%	29.2%	Varian Associates and ENTECH Corp.
Conversion efficiency of GaAs/Si medianterminated concentrator cell (350X)	26.6%	31.0%	Sandia/Varian/Stanford
Conversion efficiency of experimental Si concentrator cell (1000X)	27.7%	28.2%	Stanford
Conversion efficiency of module-ready high-resistivity Si concentrator cell (150X)	22%	25.5%	Stanford
Conversion efficiency of module-ready low-resistivity Si concentrator cell (100X)	23.5%	24.2%	University of New South Wales
Diameter of crystalline silicon material having long minority carrier lifetime (21 milliseconds)	20 mm	52 mm	SERI

Progress in Research - 1988 (Photovoltaics)

Fundamental and Supporting Research

- Achieved 19% efficiency for AlGaAs cells through cooperative project (Kopin, Research Triangle Institute, SERI)
- Created mathematical model to explain loss mechanisms in CIS and CdTe cells, revealing areas for efficiency improvements (Colorado State University)
- Performed more than 8000 material/module tests and measurements for more than 100 different organizations (SERI)
- Developed spectroscopic scanning tunneling microscope method for the direct imaging of atoms in electronic solids (SERI)
- Optimized a method to measure microvoids in good-quality amorphous silicon, to help manufacturers improve photostability (SERI)
- Grew high-quality gallium phosphide on silicon with greatly reduced defect density (SERI)
- Predicted theoretically that novel semiconductor compounds can be stabilized epitaxially, and may be useful as new photovoltaic materials (SERI)
- Initiated a cooperative effort to study single-crystal CIS cells (SERI, Institute of Energy Conversion, ARCO Solar)
- Improved technique used to measure electron energy levels (Carnegie Mellon)
- Patented the Atmospheric Optical Calibration System, a new instrument for measuring atmospheric and solar radiation characteristics (SERI)

Flat Plate Thin Films

- Quadrupled the area to 4 cm² for thin-film GaAs cells while maintaining efficiency over 20% (Kopin)
- Conducted reviews of Phase I accomplishments of Amorphous Silicon Research project; most milestones met. Awarded Phase II contracts (ARCO Solar, Solarex, Chemar, Energy Conversion Devices)
- Demonstrated CdTe device stability for 3000 hours of testing under illumination at high temperature, 70°C (Ametek)
- Developed new fabrication technique for window materials for copper indium gallium diselenide cells (Boeing)
- Found promising high-band-gap CdTe alloys for the top cell in a two-junction device (Jet Propulsion Laboratory, Georgia Tech, Ametek)
- Made a 100-cm² polycrystalline silicon module with 2.3% efficiency (Astro Power)
- Fabricated large-area back reflectors for a-Si submodules (Solarex)
- Transferred laser scribing advances to production environments (Chropal)
- Improved a-Si deposition rate by 10 angstroms per second while maintaining material quality (Glasstech Solar)

Concentrator Cells

- Delivered over 40 GaAs concentrator cells; highest efficiency 26% (Varian)
- Developed small-area GaAs cell with high voltage for military applications (Sandia)

Flat Plate Crystalline Silicon

- Completed the awards of university subcontracts under a part Sandia/SERI solicitation (Sandia/SERI)
- Achieved 19% efficiency in a 2" x 2" crystalline silicon cell that can be made more cheaply than most commercial cells today (University of New South Wales)

Module Research

- Developed "Thin-Film Module Qualification Document" and "Thin-Film Module Reliability Plan" (SERI, Sandia, JPL, PV industry)
- Assembled prototype and made initial tests of Sandia's Thin-Film Module 3 (Sandia)
- Began field testing of promising new array tracking test controller (Sandia)
- Began qualification testing of new Watsum concentrator modules (Sandia)
- Published "Qualification Tests for PV Concentrator Cell Assemblies and Modules" (Sandia, PV industry)
- Completed qualification testing of cell assemblies and modules for the ENTECH/OM/Allen project (Sandia)

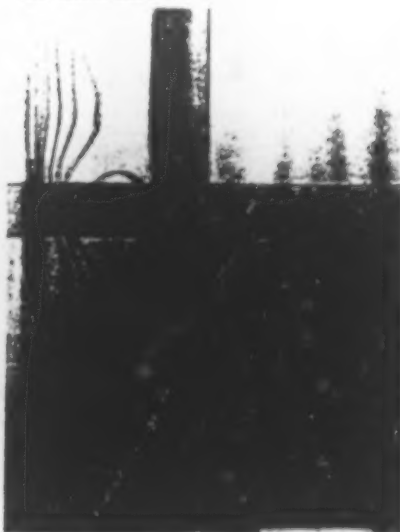
Systems Research

- Assisted U.S. Fish and Wildlife Service in establishing a PV energy system for Tern Island in the Pacific; system operating as planned; interested in more systems (Sandia)
- Developed and published "Photovoltaics for Military Applications", well-received by potential military users (Sandia)
- Continued work on Guatemala vaccine refrigeration project, and advised UNICEF, USAID, Pan American Health Organization, and others on PV projects (Sandia)
- Completed development of advanced power conditioning unit, with more than 95% dc-to-ac conversion efficiency and cost projections of \$0.08 per watt (Sandia)
- Performed detailed electrical analysis of fielded systems; developed substantial changes to PV section of National Electrical Code (Sandia)

Applications Experiments

- Awarded contracts for four Emerging Technology modules for PVUSA. Installed data acquisition system; constructed instrumentation building (PG&E, DOE, Sandia, SERI)

Solar Buildings



SEIR's convection heat-transfer laboratory showing ventilation jet in an indoor air quality test cell

Solar Energy Research Institute

Low-Temperature Heat and Mass Transfer Laboratory

Contact: Daisuke Shirohara, Thermal Systems Research Branch

The laboratory is used to study and improve methods of transferring heat and mass under the small driving forces that often exist when the sun is the energy source. The driving force can be a temperature gradient or other intensive thermodynamic differential, such as a concentration gradient.

The current laboratory setup includes an enclosed test cell that can be operated at pressures ranging from two atmospheres to low vacuum. Warm and cold water circulate through the test cell, allowing efficient heat and mass transfer with a variety of exchangers. The test cell is fully instrumented to measure all process variables and is automated to efficiently acquire data.

The laboratory can be readily adapted to study and test other low-temperature heat and mass transfer processes, especially in advanced gas-liquid devices. Processes studied and tested include vacuum drying, material degradation caused by outgassing in vacuum environments, gas sorption and desorption from liquids, and other continuous and staged separation processes.

Desiccant Dehumidifiers

Solar Energy Research Institute

Solar Desiccant Cooling Laboratory

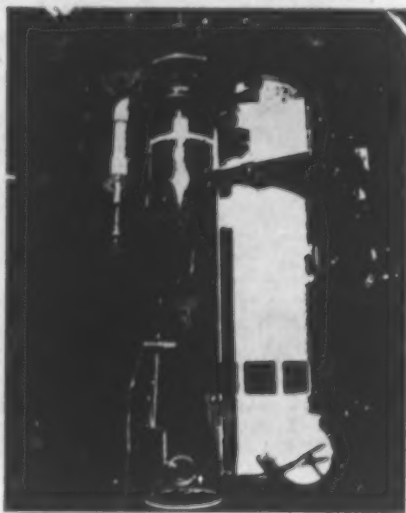
Contact: Ahmed Pasaun, Buildings Research Branch

The laboratory houses three facilities used to test materials, geometries, and components for desiccant dehumidifiers: sorption, single blow, and cyclic. All three provide controlled and conditioned process and regeneration air to test desiccant cooling systems.

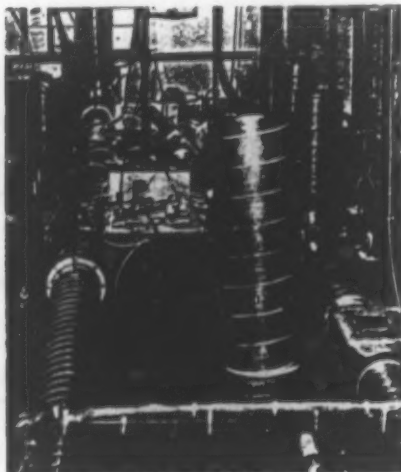
The sorption test facility measures the water equilibrium capacity and mass transfer rate of solid desiccant materials under isothermal conditions. These materials are exposed to process or regeneration air flow to attain dynamic equilibrium under a specific geometry.

The single-blow test facility generates data on transient heat and mass transfer and pressure drop for small-scale dehumidifiers with promising material and geometry combinations under adiabatic conditions. The momentum and heat and mass transfer characteristics can be measured to test the performance of different combinations of geometry and material.

The cyclic test facility is used to test advanced prototype desiccant dehumidifier components, such as



SEIR's low-temperature test cell for testing heat and mass transfer showing direct-contact condenser



GEAR's cyclic desiccant test facility with the test section in the center

a spirally wound wheel using silica gel with parallel-passage air flow. The test facility measures the performance of dehumidifier wheels under cyclic operation as a function of rotational speed, inlet air temperature and humidity, and air flow rates of both process and regeneration airstreams.

Apertures and Windows

Florida Solar Energy Center

Fenestration Research Facilities

Contact: Ross McCluney, Research and Development Division

Facilities and equipment for fenestration research include daylight availability measuring stations, a skylight testing station, a fast-response multichannel photometer, and solar calorimeters.

The daylight availability stations consist of instruments to measure and a computerized data acquisition system to analyze daylight. The Skylight Testing Station is used to test the optical properties of skylights and skylight wells. It is also used to calibrate light sensors and daylight measurements inside scale models of buildings.

The fast-response multichannel photometer can make rapid and repeated measurements of illuminance at eight locations by placing miniature light sensors

inside small or full-scale models of buildings. The instrument is controlled by a computerized data acquisition system. The solar calorimeters measure the relative solar radiant heat gains through two different fenestration systems in simultaneous, side-by-side, outdoor tests in full sunlight.

Lawrence Berkeley Laboratory

Solar-Optical Properties Laboratory

Contact: Stephen Selkowitz, Applied Science Division

The group has advanced facilities to conduct research on the optical and thermal properties of fenestration systems, shading systems, and building envelope systems. A large integrating sphere can measure the hemispherical transmittance of materials, components, and systems as a function of sun and sky conditions. The sphere can measure visible or solar transmittance for samples up to 2 ft by 2 ft. Typical uses for the integrator include measuring transmittance properties of skylight light wells, light guides; complex diffusing glazings with angle-dependent properties; and complex shading systems such as venetian blinds, fins, and honeycombs.

A luminance and radiance scanner for measuring bidirectional transmittance and reflectance of materials, components, and systems is also available for sample sizes up to 2 ft by 2 ft. The instrument measures the directional properties of visible (or radiant) flux transmitted (or reflected) through shading devices within 2- σ directions of emittance for any possible direction of uniform directional incident flux.



FSEC's model used to collect daylight illuminance measurements



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December 13, 1988

For further information:
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703-524-6100

**SOLAR BREAKTHROUGHS CAN LESSEN GLOBAL
WARMING AND BREAK DOWN TOXIC WASTES**

WASHINGTON, D.C. -- Three nationally-known solar energy experts speaking at a National Press Club briefing today, presented findings that solar energy technologies offer profound benefits for the environment. Scott Sklar, Executive Director of the Solar Energy Industries Association (the national trade association of the photovoltaic and solar thermal manufacturers and component suppliers) stated, "Solar energy can most easily be integrated into the utility sector to replace aging, costly, peak-power utility plants. This emission-free power source provides a most important step to begin cutting greenhouse gases responsible for global warming." Sklar stated further that 200 megawatts of solar thermal power is already operating in the United States, and over 3,100 megawatts (excluding hydropower) of renewable energy resources are on-line.

Dr. Robert San Martin, Deputy Assistant Secretary of the U.S. Department of Energy presented findings which indicate that solar energy applications provide less emissions, less pollutants, and use less land area than most conventional forms of energy.

The Solar Energy Research Institute's Director Dr. Harold Hubbard advised the gathering of advances in solar thermal technology which have provided important technological spinoffs in the battle to break down toxic and dangerous wastes. Field tests at the Sandia National Laboratories have successfully broken down dioxin-like compounds and chloroflourocarbons, a greenhouse gas. Such technologies offer potentially lower-cost options to deal with America's growing stockpiles of wastes.

SEIA's Scott Sklar warned that further cuts in federal research & development could undercut these new research developments. Sklar stated, "While the United States holds the technological lead in solar, and solar energy provides one of the most important energy options for our nation's future, federal policymakers must aggressively continue research and commercialization efforts."

SOLAR ELECTRIC/THERMAL ANSWERS TO THE ENVIRONMENT

A brief industry analysis of the contributions of photovoltaics and solar thermal applications in offsetting environmental degradation and climate change.

INTRODUCTION

Since the 1973 oil embargo, solar energy has grown to over a \$500 million per year industry. The most familiar, solar water heating technology, has been installed in over one million homes throughout the United States with sales reaching \$100 million in 1987. Solar thermal power technology which concentrates sunlight for industrial process heat or electricity now produces over 150 megawatts of utility-grade electricity reaching over \$200 million in annual sales in 1987. Photovoltaic technology which converts sunlight directly into electricity now is used in consumer, remote, and utility applications with sales exceeding \$100 million.

The federal research effort in solar energy totals \$56 million in FY'89 with \$35 million directed towards photovoltaics research, \$15 million for solar thermal power and approximately \$6 million for solar buildings (active and passive solar heating) research. The solar research budget has fallen from \$250 million since FY'81. Since December 1985, tax incentives for the residential uses of solar energy have expired, while the incentives for commercial (at a 10% level) applications have remained in effect and are scheduled to expire in December 1989.

Solar energy applications can greatly reduce environmental hazards and will increasingly do so over the next decade. Solar thermal applications can easily offset petroleum and natural gas for thermal applications which account for 35 percent of U.S. energy use. Photovoltaic technology is being increasingly used most cost-effectively to displace or replace diesel-fueled generators which are an unregulated and polluting energy source. Solar thermal power technology already offsets peak-power utility generation and will offset more utility-grade energy within the decade as will photovoltaics to a lesser extent. These technologies displace fossil fuels lowering greenhouse gas emissions and contributions to acid rain. Finally, new solar concentrating technologies have exhibited potential in the laboratory to breakdown hazardous wastes and greenhouse gases while photovoltaics may be used to produce hydrogen fuel, as a replacement to gasoline and aircraft fuel.

GREENHOUSE EFFECT - CAN SOLAR MAKE A DIFFERENCE?

The impact of global warming on utilities is very profound. According to Dr. Irving Mintzer of the World Resources Institute advised in Public Power Magazine that more hot/dry weather will mean increased summer air-conditioning loads and the frequency of unpredictable cold snaps and blizzards due to global warming may cause higher demand episodes in winter. The United States emits about 28 percent of the carbon gases of which 33 percent is produced by the utility sector, 23 percent from the industry sector and 11.8 percent from the residential and commercial heating sector.

As stated earlier, solar thermal and photovoltaics applications are most cost-effective for peak-power production. Currently, utility peak power generation provides the most expensive and least efficient energy. Solar thermal electric application currently produce energy at the \$0.15-0.22 per kilowatt hour range and photovoltaics can supply peak power electricity at the \$0.19-0.25 per kilowatt hour range. Utilities are increasingly looking towards solar applications for peak power due to:

- o low maintenance costs
- o modular capacity with little or no regulatory burden
- o fast development times with plants producing power within fifteen months

Over thirty U.S. utilities have research and testing programs involving solar electricity. Slow replacement of aging peak-power plants and newer peaking plants could offset over 15 percent of greenhouse gases produced by utilities.

Solar thermal and photovoltaic applications produce no greenhouse gases (carbon dioxide, chloroflourocarbons, methane or nitrous oxides). The fastest approach to offset fossil fuel burning by utilities is through replacement or addition of peak power plants by solar electric applications. Replacement of fossil baseload generation by significant proportions is unlikely in the near term.

Peak power shaving has been achieved through the use of solar and energy conservation. Over one million homes in the United States have solar water heaters. Several utilities have developed programs to encourage solar water heating as an efficient way to offset the need for increased peak-power generation capacity particularly during mid-day.

SOLAR ENERGY INDUSTRIES ASSOCIATION

Both solar thermal and photovoltaic technologies have the unique property of having the highest production at noon which is the highest electrical demand of most utilities.

CLEAN AIR

Fossil fuel displacement has been achieved today through the use of photovoltaic and solar thermal applications. Aside from peak-power plants, diesel/propane/kerosene are used throughout the United States to power generators for remote power sources. State and county highway commissions utilize diesel powered road lights and builders utilize diesel generators to power tools and lights. Most remote generators are unregulated and highly inefficient. Emissions from remote generators exceed those of automobiles. Photovoltaic generators are being produced by a wide number of photovoltaic companies. Reduction of remote-electric generators burning fossil fuels could significantly reduce air pollution.

Gasoline vehicles account for 31.2% of carbon dioxide emissions as well as significant amounts of nitrous oxides and photochemical oxidants. Photovoltaics are being researched as the main application to produce hydrogen fuels. The breaking of the chemical bonds of water by electric charge will become economical after the year 2000. Hydrogen fuel will ultimately replace fossil fuels as the fuel-of-choice due to its immense power and virtually no pollutants.

In regard to acid rain, coal plants which utilize scrubbers tend to have the highest carbon dioxide emissions. Incorporation of solar applications will tend to have a positive effect of lowering acid rain for peak power plants.

WASTE BREAKDOWN

Solar thermal technologies are now being tested as an important new way to breakdown toxic wastes and freon compounds, chloroflourocarbons which contribute to the greenhouse effect.

The U.S. Department of Energy and the U.S. solar thermal industry are cooperating in a unique set of tests to use solar concentration to breakdown dioxin-like compounds. Preliminary computer modelling at the Solar Energy Research Institute lead to actual field tests at the Sandia National Laboratories. It has been found that many chemical compounds react differently under equal temperatures but in the high concentration of sunlight. The experiments found that dioxin-related compounds will breakdown in the presence of solar-concentrated sunlight to EPA-acceptable levels at the 800 F level while not so at equal temperatures without solar concentration.

Similar tests will also be made to breakdown chloroflourocarbons (CFC) through solar concentration. CFCs breakdown naturally in the presence of sunlight in the atmosphere. This CFC breakdown is a significant cause of global climate change. Tests will be performed to see if there are economical processes using focussed sunlight to breakdown freon compounds on earth before they enter the atmosphere. These tests may offer an approach to collect certain containers, airconditioning units, and freon wastes for reprocessing.

Solar concentration for chemical breakdown, the new creation of material surfaces, and powering lasers has been achieved already. Increased research and development is necessary to pursue these promising achievements in order to commercialize the technology.

CONCLUSION

Solar thermal and photovoltaic technologies are one of the most promising set of technologies to offset fossil fuels in peak power and remote electric generation. These technologies can also offset peak power generation by utilization during high demand times -- at mid-day. Almost every major utility company in the United States is involved in photovoltaic or solar thermal research, testing and incentive programs.

Most experts agree that it is unlikely that significant amounts of fossil fuels can be displaced for baseload electric generation plants in the near future. However, peak-power plants, which generally comprise the highest cost and most inefficient plants, have the highest potential for replacement. Solar thermal and photovoltaics appear to be a most viable alternative due to the low maintenance, modularity, quick construction, and environmental assets of these applications.

SOLAR ENERGY INDUSTRIES ASSOCIATION

Utilities will also continue to utilize peak-shaving approaches to offset the need for more highly costly peak power generation. Solar water heating already is encouraged by many utilities as an optimum peak-shaving approach. Passive solar application such as daylighting are also being encouraged.

Solar technologies will also be used in the foreseeable future to breakdown hazardous wastes, and produce hydrogen fuels.

Although research for solar energy has been cut by over 70 percent over the last eight years, solar technologies represent the most important technological answer to global climate change. Today, our international competitors have surpassed the United States in their federal R&D programs. In order for the United States to effectively displace fossil fuels and maintain our competitive edge, a range of positive policies must be implemented. Incentives should include level federal R&D funding, maintenance of commercial tax incentives, continued encouragement for utility interconnection, and incorporation of investment incentives in conventional loan programs.

PROGRESS AND IMPACT OF RENEWABLE ENERGY*

Dr. Robert L. San Martin
Deputy Assistant Secretary for Renewable Energy
U.S. Department of Energy
Washington, D.C., U.S.A.

INTRODUCTION

I am pleased to be here today to discuss the progress being made in the development and use of solar and renewable energy technologies, and to explore some of the impacts renewable energy can have on U.S. energy security and the environment. Although not well known, renewable energy is making a surprisingly significant contribution to U.S. energy needs and the U.S. economy. Renewable energy today supplies enough energy to run the country for one month. That's about \$18 billion worth of energy. In terms of electricity, renewable energy supplied enough energy to power 58 million homes for a year. Renewable energy is today making a bigger contribution than synfuels, than clean coal, than fuel cells, or even nuclear. It is easy to overlook renewable energy's accomplishments because it is difficult to demonstrate renewable energy's potential by pointing at a single plant or a single area of the energy system and saying, that is what renewable energy does -- it makes electricity, or fuels cars, or heats your house. Renewable energy can do all those things. It also comes in modular increments that closely match energy demand, don't require massive long term capital commitments, and can be brought into production relatively quickly -- these are great competitive advantages for an energy system, just difficult to explain in a few words.

* Speech presented at the National Press Club, Washington, D.C., December 13, 1988

Solar and renewable energy includes a wide variety of technologies used to capture and transform naturally occurring wind, sunlight, geothermal, ocean thermal gradient, falling water and organic biomass into fuels, heat and electricity. Biomass, in the form of wood, and hydropower from large dams, have been in use for many years and make a large contribution to the nation's energy supply. There are many large and small companies supplying equipment to tap these resources and many users of the energy they produce, so there is a certain stability to their development and potential. Other technologies, like photovoltaics, solar thermal, geothermal, and wind are just beginning to show their potential in commercial market niches, a good sign for future expansion.

For example, U.S. photovoltaic manufacturers have reached annual sales volumes of \$40 million, adding 8 MW annually to the world's power supply every year. PV systems are delivering energy at an annualized cost of 25¢ per kWh, an attractive price for regions without an established power grid. PV systems are being installed in many countries for lighting, water pumping, and medical refrigeration. U.S. wind energy sales are about \$10 million annually, and 1500 MW of wind power has been installed in the U.S., delivering energy at annualized costs as low as 8¢ per kWh. Over the next five years, the growth potential for wind power has been estimated at 300 to 400 MW per year internationally.

Solar thermal systems now represent an installed capacity of 148 MWe, and should be at 200 MW by end of the year. New systems offer an annualized delivered energy cost of less than 12¢ per kWh. Geothermal energy, on the other hand, is providing a competitive, renewable alternative for base-load

plants in the western U.S. Over 2200 MWe has been installed in the U.S. delivering electricity at an annualized cost of 5¢ per kWh. Worldwide, the geothermal industry has installed over 5000 MWe, just a fraction of its potential.

In the U.S. municipal solid waste (MSW) to energy is producing over 850 MWe at a typical delivered energy cost of 6¢ per kWh. This investment will grow very rapidly since waste-to-energy plants reduce landfill requirements as well as produce power for urban centers. The same pressures are felt by every country in the world, as populations move more and more to urban areas and energy is required to maintain or improve services.

RESOURCE POTENTIAL

These successes only foreshadow renewable energy's ultimate potential. For example, our road surfaces alone absorb more than twice as much solar energy each year as the total U.S. energy requirement. The issue is not a shortage or limitation of energy resources but a limitation in technology to collect and convert the resource to useful energy. The Office of Renewable Energy recently examined the availability and accessibility of renewable resources as a potential energy supply resource indigenous to the United States, and the preliminary findings promise to be eye-opening. The basis for the study has been to characterize the availability of energy sources in the U.S. per traditional resource/reserve classifications of total resource base, accessible resource base, and reserves as defined by the U.S. Geological Survey.

The total resource base, the physically available (both identified and undiscovered) resources regardless of whether or not they can be practically or economically extracted, is made up largely by renewable energy sources, nearly 93% of the U.S. total, or over 599,000 billion barrels of oil equivalent. However, no energy resource can be fully accessed because some portion may be physically unrecoverable. As an example, when reasonable allowances are made for land areas which are unsuitable for solar energy or biomass utilization in the U.S., the "accessible" photoconversion resource -- with current extraction technology -- is roughly equivalent to 74,000 billion barrels of oil equivalent, or about 5,600 years of energy at current U.S. consumption rates. Similar evaluations of the measured or estimated accessible resource for other renewable energy sources indicate that total accessible renewable resources may approach 80,000 billion barrels of oil equivalent -- as a recurring resource potential, not one that is finite.

By comparison, the estimated accessible resource base indigenous to the U.S. for coal, shale oil, petroleum, natural gas, and peat is some 8,800 billion barrels of oil equivalent -- or roughly 10% of the accessible energy resource total for the United States.

Not all accessible resources are economically recoverable either. By definition, energy reserves are the economically viable subset of the accessible resource. The United States has an energy reserve of over 1,105 billion barrels of oil equivalent, which would provide for approximately 75 years of national energy consumption at 1987 rates of usage. The great majority -- approximately 82% -- of the U.S. energy reserve total consists of

coal, which is being used extensively. Of the other energy sources, which collectively comprise an additional 17% of the total U.S. energy reserve, renewable energy is the largest component at 11%, followed next by oil and gas at 6%, and uranium.

The total U.S. energy reserve constitutes only about 15% of the estimated total accessible energy resource. This indicates that there is a large amount of available energy in the U.S. that cannot yet be economically tapped as an energy supply due to current extraction or conversion efficiencies or technological constraints. In the near term, energy consumption trends are expected to continue to concentrate on fossil fuels, which dominate reserves. Over the long term, research and development of renewable energy conversion technologies, which will improve efficiencies and lower system costs, is expected to provide the U.S. a tremendous opportunity to move in the direction of utilizing the nation's abundant, accessible, renewable resources.

Even though renewable energy presents technical and resource advantages, it is competing in an energy market where prices are low. But the current energy situation is far from immutable, and long-term trends are favorable for the deployment of renewable energy technologies. The U.S. and the world face challenges in ensuring energy security and in meeting future electrical demand, while also maintaining and improving the environment. In all three of these areas renewable energy offers technical advantages. Over the long term renewable energy's massive resource base and the pace of research and development will tend to bring renewable energy's prices down to the point where they can better compete with established technology.

ENERGY SECURITY AND RENEWABLE ENERGY

The U.S. demand for foreign oil is now over 40% of our total petroleum requirements, up 11% from a year ago. And if current trends continue, oil imports will rise by another 6% by 1989 to 2.3 million barrels of crude oil per year. At the same time, domestic oil production has fallen. The U.S. transportation sector is consuming 20% more oil than it did in 1974. In 1987, U.S. automobiles burned the equivalent of five supertankers of gasoline per day, up 5% from only two years before. As the U.S. population has grown, the number of vehicles on the road has also grown dramatically -- at a time when fleet average "MPGs" have held steady -- with a net effect of an increase in energy consumption.

With rising oil imports, there is a growing need to expand our use of alternative transportation fuels. The development of methanol and ethanol from recurrent biomass resources such as wood and corn has grown in the U.S. Currently, over 50 ethanol plants produce 800 million gallons per year. Worldwide production of ethanol is over 3.7 billion gallons. This ethanol supply has buttressed the nation's fuel supply and has resulted in reduced environmental emissions. But, the U.S. is still expending \$50 billion annually to import oil, or about one quarter of our annual trade deficit. In reviewing the expenditures on energy trade on an international basis, an enormous amount is spent annually to satisfy imported energy needs.

OUTLOOK FOR ELECTRICITY AND RENEWABLE ENERGY

The U.S. electricity industry is moving into a new era. The industry is experiencing major reservations about building additional large-scale projects due to significant capital costs and the uncertainty of future electrical demand. How will our future electrical requirements be met? Initially, by integrating conservation and demand-side management practices in all electrical end-use areas. But conservation and demand control will not be enough.

From the supply side, cogeneration and renewable energy systems are formidable players in helping to meet future electrical capacity needs. More than 24,000 MW, or 4% of the nation's capacity are now owned by independent power producers. Another 28,000 MW of independent power are under construction or planned -- half of which use renewable-energy resources or natural gas. In fact, nearly 15% of projected new electrical capacity in the U.S. to be added in the next 10 years will be either cogeneration or renewable projects. As this trend continues, valuable experience is continually gained to allow easier and more reliable integration into the existing electrical industry framework. And as the utility industry is further deregulated, as competition grows, and as environmental concerns change, the advantages of renewable energy systems will continue to push them to the forefront of consideration.

THE ENVIRONMENT AND RENEWABLE ENERGY

Facts are stubborn things. Responsible energy professionals must be concerned with system efficiencies, cost, heat rates, maintainability, and reliability. Environmental impacts must also be considered as a major factor in responsible energy system options. Last week I chaired a meeting of the Renewable Energy Working Party and arranged for briefings to the International Energy Agency of results of a comparative investigation of varying energy options that account for environmental emissions over entire fuel cycles, of energy systems including: resource extraction and processing, construction, conversion (operation), and decommissioning cycles. Of particular interest from the investigation is the level of atmospheric emissions of carbon dioxide (CO₂), a greenhouse gas, resulting from the deployment of energy technologies. In general, it is estimated that worldwide emissions of carbon to the biosphere total approximately 5.5 billion tons per year. The combustion of fossil fuels in the U.S. alone produces about 25% of the world's total CO₂ emissions -- over 1 billion tons per year. Of the 1 billion tons of CO₂ that is emitted from burning fossil fuels in the U.S., the transportation sector is responsible for approximately 27%. About 28% comes from the combustion of coal and other fossil fuels in the electric utility sector, and industrial and building energy requirements account for the remaining 45%.

In examining the various fuels available, both fossil-related and biomass, it is evident that there are options. The most widely available fuel in the U.S. is, of course, coal. Coal, on the basis of energy derived from combustion,

emits approximately 100,000 tons of CO₂ into the atmosphere for every trillion BTUs derived.

The combustion of biomass-derived transportation fuels such as methanol and ethanol also releases CO₂, but less than many fossil-fuel options, and almost none when biomass fuel production is well managed and regenerated on a sustainable basis -- serving as a carbon sink that can offset emissions during combustion. In fact, a methanol or gasoline plant using biomass grown from a short-rotation energy plantation would actually reduce atmospheric CO₂. The key of course in using biomass resources worldwide is "managed" use. The mining of biomass, known as deforestation, is occurring at an alarming rate and should not be confused with managed biomass resources which can provide the world with a significant amount of environmentally attractive energy.

To extend the emission comparison, hydrogen produces no CO₂ emissions during combustion. However, hydrogen must be "produced," and conventional processes such as steam reforming using natural gas as a feedstock will still have associated emissions. But when renewable energy technologies are used in the production of hydrogen, no CO₂ emissions need to occur, either during processing or combustion.

If CO₂ emissions from resource extraction and fabrication of energy systems are considered along with the emissions from operation, the comparative position for renewable energy continues to strengthen. In a comparison of electric power technologies, coal-fired power plants -- both of conventional and advanced design -- are responsible for significant emissions of CO₂ ranging

from 800 to over 1000 tons per GWh when coal extraction, plant fabrication, and combustion are considered. By contrast, a power plant using photovoltaics has negligible resource extraction and operation-related emissions and minimal device fabrication-related emissions, and a biomass-fired plant's emissions are completely offset by fuel regrowth.

RENEWABLE ENERGY TECHNOLOGY AND OPPORTUNITIES

Again, facts are stubborn things. Already renewables are a significant part of the energy mix, annually providing over 9% of energy in the U.S. and 60 quads worldwide. More than 15,000 homes now receive their electricity from photovoltaic systems. Photovoltaic systems are powering hundreds of villages to run water pumps, refrigerators, electric lights, and communication systems. For many of these areas, photovoltaics is the preferred option for generating electricity. In the early 70's the highest photovoltaic cell efficiency was approximately 15%; now it is over 30%, comparable to conventional energy technologies. Today, in the U.S. more than 70 electric utilities are actively involved with photovoltaics, with the ultimate goal of using photovoltaics in utility-scale generating systems. Research in PV materials is intended to reduce the delivered cost of PV-generated electricity to less than 10¢ per kWh in the mid-1990s, opening up an international sales market measured in the billions of dollars.

The installed capacity of solar thermal systems in the U.S. is expected to grow to over 500 MW in the next few years. There were no commercially successful solar thermal companies just 15 years ago, but now LUZ has independently

developed over 140 MW of solar thermal capacity and expects to be at 200 MW by end of year.

Geothermal energy is now being tapped by at least 17 countries for electricity production. Worldwide electrical capacity of geothermal systems are expected to increase to 10,000 MW by 1995. In 1971, when U.S. research began, there were only 131 MW of capacity in the U.S.; in 1988 that number has increased to 2574 MW.

In California, a trip through the Altamont Pass, the Tehachapi Mountains, or the San Geronio Pass -- with over 15,000 turbines collectively -- is a graphic statement of the contribution made by wind energy to the U.S. electrical supply. Wind energy electrical capacity is expected to grow by 100 MW annually in Europe. India has plans to install 5,000 MW of wind capacity by the year 2000, while China expects to add 100 MW in the next few years. From 1982 to 1987 wind energy production in the U.S. has climbed from insignificant to 4 billion kWh. New airfoil shapes and the use of composite materials in turbine blades are expected to increase the efficiency and reliability of wind energy machines. Research now underway is likely to reduce the cost of delivered energy from wind systems to 4¢ per kWh, again expanding the market potential of this large resource.

Numerous types of biofuels and biofuel technologies are providing cost-effective energy for a variety of end-use sectors, including buildings, industry, and transportation. In 1974 landfills were not an issue and there were only three waste to energy plants in the entire U.S. Today the stock of

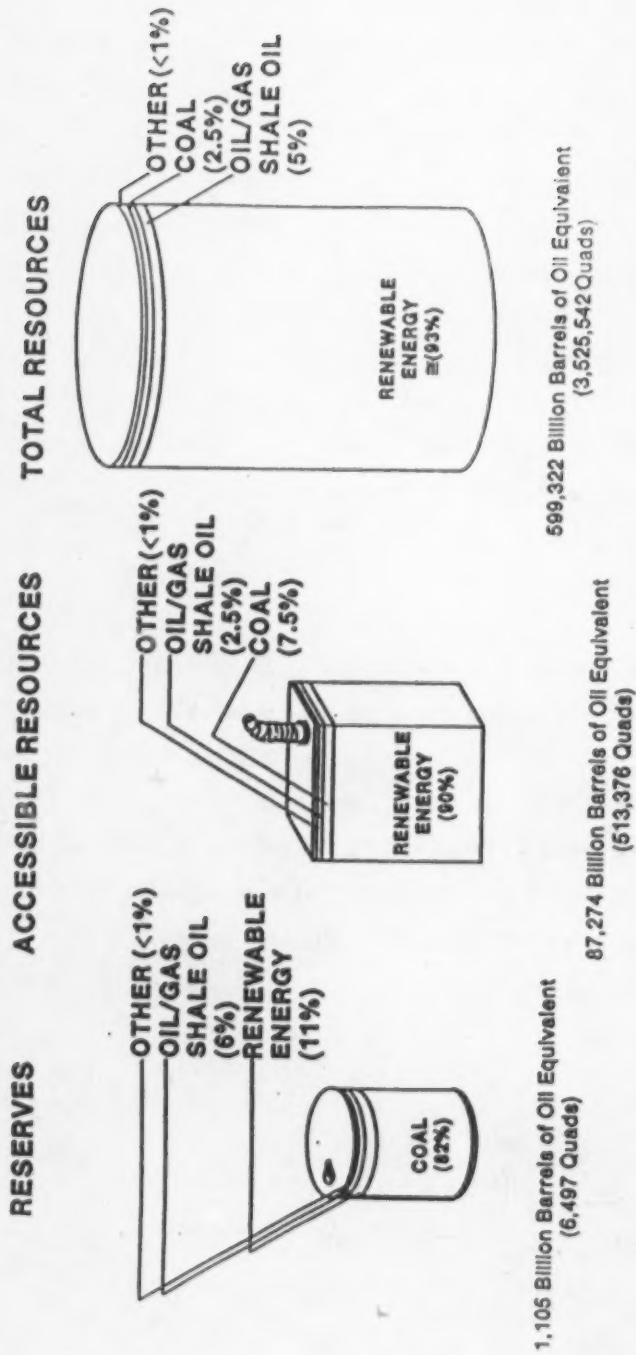
waste-to-energy plants has grown to 120. The pulp and paper industry in the U.S. meets more than half of its energy needs with biomass resources. Several U.S. utility companies have built power plants designed to burn wood that is harvested from managed forests. In the early 1970s wood to gasoline was just a concept, today it is a laboratory technology, and tomorrow it may be a major source of transportation fuel.

Sophisticated glazings now under development for buildings will change from light to dark -- and back again -- with high insulating values and the ability to redirect sunlight deep into a room. Windows of the future will be net energy producers in buildings even in cold climates.

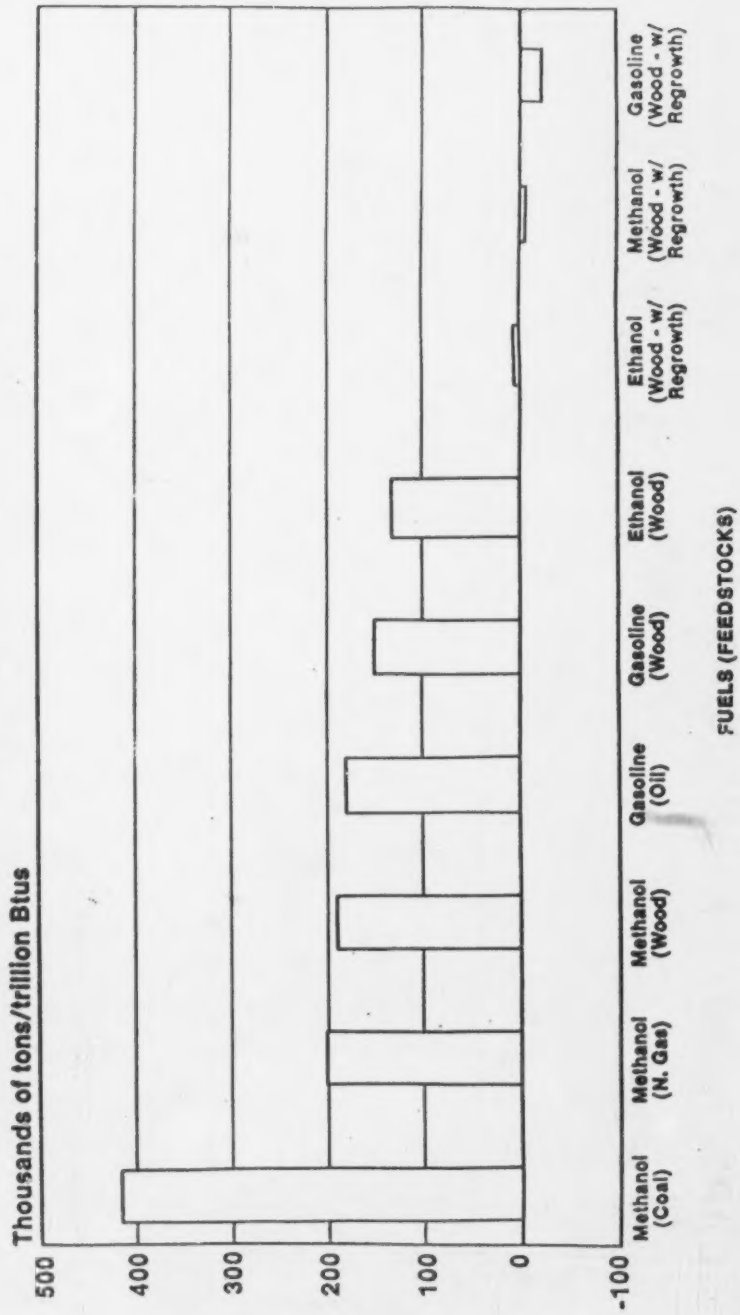
CONCLUSION

I characterize what has happened in RE over the last several years as a time of quiet progress. Continued progress driven by the results of research and development. It is clear that technological change is a certainty -- it has happened in the past, it is happening now and it will continue in the future -- and renewable energy is in the mainstream of technological progress. At home and abroad, the opportunities in renewable energy are limited only by creativity, commitment, and dedication.

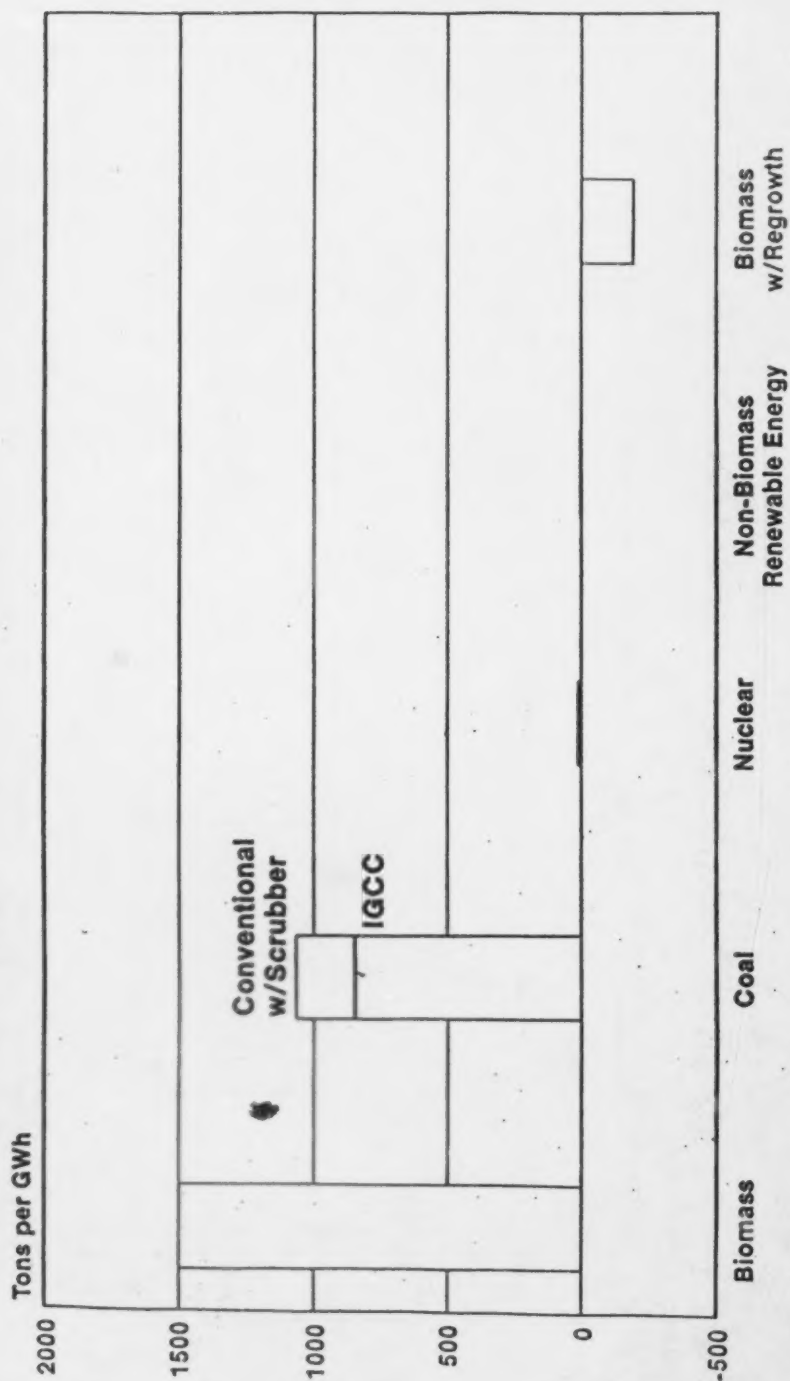
U.S. ENERGY RESOURCE/ ESTIMATES



CARBON DIOXIDE EMISSIONS: LIQUID FUELS



CARBON DIOXIDE EMISSIONS: ELECTRIC GENERATION



Senator WIRTH. Well, gentlemen, Mr. Sklar, thank you very much to all of you. Thank you very much.

There will be a variety of questions from members of the committee and from the committee overall which we will be submitting to you for the record which will be left open for your responses.

It has been a long morning, and we have another panel coming on this afternoon. And I wanted to thank you all for being here and for your support of the legislation. Many of you have provided a lot of ideas to us as we put together this bill. We have a long way to go, obviously, but I didn't hear anybody this morning that wasn't saying that we ought to particularly pursue the items that you, Dr. Rosenfeld, and you, Mr. Wolf, were presenting in terms of conservation. I think there is broad agreement on that. And I would hope we can just as broad agreement on the aggressive pursuit of renewables. Thank you all very much.

The committee will come back in for our final panel at 2:00 o'clock.

Thank you all very much.

[Whereupon, at 12:57 p.m., the committee was recessed, to reconvene at 2 p.m., this same day.]

AFTERNOON SESSION

Senator WIRTH. Thank you very much for being here.

Our final panel of the day: Sue Hickey, the Assistant Administrator of the Bonneville Power Administration; Mr. William Robertson, Vice President for Planning of Pacific Power & Light; Mr. Stephen Wiel, a commissioner of the Nevada State PUC and Chairman of NARUC's Conservation Committee; and Mr. Bill McCollam, President of Edison Electric. Gentlemen and Sue, thank you very much for being here. We appreciate your coming.

Ms. Hickey, why don't you start. You all know the rules of the committee. We will include your statements in full in the record, and would hope that you might summarize them in whatever way you think would be most helpful. Thank you.

STATEMENT OF SUE F. HICKEY, ASSISTANT ADMINISTRATOR, OFFICE OF ENERGY RESOURCES, BONNEVILLE POWER ADMINISTRATION, DEPARTMENT OF ENERGY

Ms. HICKEY. Thank you. It is a pleasure to be here today to talk about Bonneville's experience principally in the area of conservation. The Department of Energy is in the process of developing its position on the bill, so I am not going to be commenting on that.

Let me start with just a few items of background on Bonneville. We are a Federal agency and part of the U.S. Department of Energy. We were established to market power from the Federal facilities in the West; 85 percent of Bonneville's power system is hydroelectric. We are a wholesaler of electricity to 167 different customers that are made up of public and private utilities, as well as direct sales to industries in the region. We are located principally in Washington, Oregon, Idaho and the western part of Montana.

In 1980 the Pacific Northwest Electric Power Planning and Conservation Act was passed that, among other things, directed Bonneville to stand ready to meet the power needs of the northwest. The

two features of the Act that are most relevant for what we are discussing today are: (1) it directed one of the first experiments in least cost planning, and (2) it directed treatment of conservation as a power resource. What I am going to be talking about principally is our experience on implementing conservation as a resource.

Starting off with a perspective on the conservation resource, as I said, we use a least-cost planning framework. This means that our first step is to put all power resources, and that includes nuclear plants, coal plants, hydro facilities, cogeneration, as well as conservation, on comparable footing in terms of the amount that is available at a certain price, taking into account such things as lead time, environmental impacts and other features.

The second step is to figure out how much power you need.

The third step is to figure out which stack or mix of resources most cost effectively meets those future needs.

I probably should observe at this point that this is one of the first struggles that we had with conservation. When we started in 1980, there was not a whole lot of experience with the conservation resource. It is fairly difficult to quantify precisely how much conservation would be available from a certain measure from a certain sector.

Over the last eight years, we have basically determined that there are somewhere between 3,000 and 4,000 megawatts of conservation that are going to be available in our region by the year 2010. The date is important because that conservation estimate can be higher or lower depending on the load growth that is experienced. So, in the range of forecast that we see in 2010, we think we have 3,000 to 4,000 megawatts that are least-cost and will be developed first in the region.

To date, through 1988, Bonneville has developed 220 megawatts of conservation, and basically that is a misleading figure because that 220 megawatts will grow to 1,300 megawatts by 2010. The reason for that is that we have put significant effort, as I will discuss later, into codes for new residences, and new commercial buildings. In addition, we have some industrial programs in process, and the savings in these programs will grow over time. So, the 220 megawatts will become 1,300 megawatts.

In addition to what we have already developed, we project that there are somewhere in the range of 1,500 to 2,000 megawatts of additional conservation that are there to be developed before other resources.

As I said, the conservation resource has been demonstrated to us to be least-cost. That has not meant, by any stretch of the imagination, that everything has been easy or that it has been free. We have spent \$750 million so far on conservation, and we will spend a billion dollars by 1992.

I would be tremendously remiss if I failed to mention that we deliver these programs through the 167 customers that I referred to earlier. In addition, the State energy offices, as well as local governments, have participated extensively in the delivery of programs. So, there is quite an infrastructure for delivering conservation programs in the Northwest.

Let me spend just a few minutes going over by sector what we have done and where we have accomplished significant savings so that you get an idea of the scope of our programs.

The largest savings—of the 220 megawatts that I mentioned, 120 of those are in the residential sector. That principally comes from retrofit or weatherization of existing homes. We have directly weatherized over 200,000 homes in the Northwest. We think that is somewhere between 60 and 70 percent of all the homes that we are going to be able to weatherize given the kind of market constraints that we see.

We ran an extremely interesting major research program called the Hood River program with Pacific Power and the Natural Resources Defense Council. We were very concerned as we started into the overall conservation effort that we thought programs would take a very long time, 15 to 20 years, something like that, to develop the full potential of a resource. And we were having significant regional debates about cost effectiveness and how to approach program design. The Hood River program essentially was structured to determine how quickly you might develop something as dispersed as residential weatherization resources if you focused on an intensive marketing effort in one community.

The second objective was basically to see how far we could push cost effectiveness. We were perhaps not including some measures in our regular weatherization program, such as triple-glazing or very, very high levels of ceiling insulation, that might in fact be cost-effective. As a result of this experiment, which was a three-year, \$20 million experiment, we ended up concluding that the marketing and the focus on one community was extremely successful in rapidly delivering a lot of savings. We got 80 to 90 percent of the homes in that one community weatherized in that period.

The other thing that we found is that this was extremely costly. It cost double what our existing weatherization program was costing. And, in fact, there were some measures that were not cost-effective the way we were considering that in the region. But the positive side of that is the performance of the homes after we weatherized them was equivalent to new homes that were being built at that time in the region. It was an extremely important research project for a lot of reasons.

In the existing commercial sector, we have saved——

Senator WIRTH. Who paid for that weatherization?

Ms. HICKEY. Bonneville essentially paid for the weatherization. Pacific Power implemented the program and Hood River Electric Co-op assisted as well.

Senator WIRTH. And where did the cost of that then come from?

Ms. HICKEY. Bonneville, in order to make the marketing experiment work, agreed to pay 100 percent of the costs.

Senator WIRTH. Where did that money come from?

Ms. HICKEY. Ratepayers of Bonneville.

Senator WIRTH. So, that was built into the rate base.

Ms. HICKEY. That's right. All of the \$750 million that I am referring to is rate based.

In the existing commercial sector, we have saved 55 of the original 220 megawatts that I talked about saving to date. This represents over 5,000 buildings that have been audited and retrofitted.

This has been a very difficult sector for Bonneville, and I would be surprised if it isn't principally because of the complexity of large commercial buildings, discovering how to save energy in those buildings, and how to audit them effectively, but also because of the relationships between owners and tenants and turnover in buildings. We have been through a series of three or four different pilot efforts and are just now setting up those program structures that are going to be the major delivery mechanisms for us in the future.

In the existing industrial sector, we have saved 45 megawatts to date. That represents some 50 plants. As you can probably imagine, there is a lot more savings per plant in the industrial sector certainly than in a dwelling or in a commercial building. So, it represents a very effective focus on the industrial sector.

Our major program to date has been with the aluminum industry. It is called the Conservation Modernization Program in which we had a dual objective of achieving conservation savings from the aluminum plants and, in addition, causing the facilities to be modernized so that they would operate more efficiently and would be more competitive on world markets. To date there are 10 plants. Every plant in the region has signed up for the program. In its first year it saved 40 megawatts. We are anticipating over the life of the program that it will save something like 170 megawatts.

The investment for Bonneville ratepayers there will be \$100 million. We are thinking that the aluminum industries probably will spend on the order of \$400 million over the period making capital improvements to their plant.

Let me spend just a minute talking about new residential and commercial. The 1980 Power Act gave some specific, unique authorities to the Planning Council which it also established to set model conservation standards in residential, commercial and industrial sectors. The standards have been established. We have been on about a five-year path to try to get those standards adopted in the region. And the lessons learned here have been somewhat important in terms of the market and the items that Senator McClure referred to this morning having to do with incentives versus coercion.

We are four years into a program of providing incentives to both homeowners and builders in the region essentially to cause current building practice to become more efficient so that codes can be adopted by local or state jurisdictions. We found, as we started into this, that the reality of the marketplace was that codes follow building practice. So, we spent significant money in developing marketing and incentive programs that to date have resulted in over 7,000 homes in the region being built to these model conservation standards, and over 100 buildings which exceed the commercial standards. And in this way, we think that we can be very effective in ultimately getting the codes adopted.

In conclusion, there are really two principal areas that I think have been extremely challenging in terms of developing the conservation resource. The first one had to do with the reliability and the predictability of the resource. Bonneville and its customers have taken a very rigorous approach to developing pilot programs. We

evaluate every program that we run, and we even do end-use metering to actually meter savings of energy through a program.

What we do is we look at how much energy is consumed before a program and how much energy is consumed afterwards. We monitor to see what costs were actually expended in the program, and we have even gone back three, four, five years after a program to be sure that the savings persisted, that it is not something that happens for one year, but doesn't happen for five years.

Through this sort of rigorous effort, we have concluded that conservation is a reliable resource. You can predict the savings and the savings do persist over time, which is not at all to say that every program we have ever run has been a resounding success. We have made our share of mistakes, but essentially this kind of approach allows you to correct those mistakes. And in that way, I don't think conservation is different than any other resource. It has its very, very beneficial effects, and there are things that you need to watch carefully.

The second thing that has been a significant learning experience has had to do with the marketplace and acceptance of consumers. The utility business is more and more a service-oriented business, and in some of our initial attempts we found they were taking too much of a regulatory approach. And I think through time we have more successfully integrated conservation. While it is a resource perhaps from the power system's perspective, it is a service from the consumer's perspective, and those things have worked together very successfully.

So, the bottom line for us is that conservation is not only a reliable resource, it is also the least-cost resource and one that Bonneville intends to develop before others to meet regional power needs.

[The prepared statement of Ms. Hickey follows:]

Statement of Sue F. Hickey
Assistant Administrator
Office of Energy Resources
Bonneville Power Administration
United States Department of Energy

Hearing on S. 324
"National Energy Policy Act of 1989"
Before the Committee on Energy and Natural Resources
United States Senate

March 14, 1989

Introduction

Mr. Chairman and members of the Committee, I am pleased to appear today to provide you with the background and experience of the Bonneville Power Administration (BPA) in conservation and renewable energy programs. The Department of Energy is in the process of developing its position on S. 324, and I am not in a position to comment on the bill at this time.

The Office of Energy Resources, one of six offices in BPA, prepares load forecasts and resource plans for BPA, develops all new resources (including conservation) and provides oversight of operating hydroelectric and nuclear resources. In the conservation area, the Office of Energy Resources plans, designs, tests, implements, and evaluates programs that produce load reductions through more efficient use of electricity. Such programs present information and financial incentives to generators, transmitters, and end users of electricity for the purpose of motivating them to use and invest in (1) measures that increase the efficiency with which electricity is used, generated, or transmitted, and (2) measures that employ renewable resources to displace consumption of electricity at the point of end use.

Background

BPA, an administrative agency within the United States Department of Energy, was created by Congress in 1937 to act as marketing agent for power from the Bonneville Dam. By subsequent legislative and executive

acts, BPA has been designated to market the power from the Federal facilities in the Pacific Northwest, and authorized to acquire and market power from non-Federal hydro and thermal projects. The non-Federal hydro and thermal projects, in which BPA currently has an interest, have been built and are operated by the region's public and private electric utilities.

BPA serves the States of Washington, Oregon, Idaho, and Montana west of the Continental Divide, plus small adjacent portions of California, Montana, Nevada, Utah, and Wyoming. It is headquartered in Portland, Oregon. The full service area covers about 300,000 square miles and has a population of nearly 9 million persons. BPA has 167 wholesale power customers--37 municipalities, 28 public utility districts, 55 cooperatives, 9 investor-owned utilities, 17 industrial firms, and 6 Federal agencies in the Pacific Northwest; and 15 utilities outside the Pacific Northwest.

Under the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (PL96-501), BPA was assigned the responsibility of meeting the future growth in demand for electricity in the region by acquiring new power generating capability and by implementing conservation measures. This Act also mandated the formation of the Pacific Northwest Power Planning Council, an interstate group representing Oregon, Washington, Idaho, and Montana, and gave it two basic functions: (1) the development of a 20-year regional power plan as guidance for BPA, and (2) the development of a fish and wildlife plan. The Act also established one of

the first least cost planning frameworks in the United States. Naturally, BPA's resource planning and acquisition over the last 8 years has been directly influenced by the Act and the Power Planning Council.

As will be discussed below, BPA has approached the acquisition of conservation with a necessary mix of initiative and prudent concern for the cost-effectiveness of programs, while developing a thorough least cost planning process.

The Conservation Resource

BPA has handled the process of planning, designing, and implementing conservation programs in a standard least cost planning framework. First, significant effort is expended in characterizing conservation and other resources in terms of the amount available at a certain price. Next, a need for power is determined through an examination of load forecasts and current resource capability. The next step is to examine the resources that may be available to meet the need for power, including the cost, size, lead time for acquisition, and the compatibility with the power system. From this array of resources, a plan to acquire the least cost resources which satisfy these criteria is developed.

Eight years of planning and analysis of resources in the Pacific Northwest has demonstrated that a large block of conservation is both compatible with the requirements of the power system and is least cost for the region, which means it is being developed first to meet future load

growth. Over 220 MW of conservation savings have been acquired through 1988, including 120 MW of residential savings, 55 MW of commercial savings and the remainder either industrial or irrigation savings. In addition, BPA has sponsored programs supporting more stringent residential and commercial building codes and developed industry contracts which should contribute to over 1,300 MW of savings by 2010. In addition to these accomplishments, BPA has concluded that there are 1,500-2,000 MW of additional conservation savings which are least cost and awaiting development.

From 1981 to 1988, BPA invested approximately \$750 million in development of the conservation resource. BPA plans to invest approximately \$80 million per year in conservation savings for the next several years resulting in an investment of over \$1 billion by 1992. Over the last 9 years, BPA has run more than 32 programs or demonstration projects. These programs have addressed retrofit and new energy uses in all sectors: residential, commercial, industrial, and irrigation. The range and timing of programs can be seen from Figure 1.

BPA's programmatic accomplishments can best be illustrated by briefly describing our approach to the major electrical use sectors.

Conservation Program Accomplishments

Existing Residential:

It is important to realize that almost half of the housing units in the BPA service area are heated with electricity; so efficiency of existing

homes is an important resource. A series of residential retrofit programs has directly weatherized over 200,000 homes resulting in savings of approximately 120 MW's of reliable energy at a cost of \$480 million. Included in these efforts was a major demonstration and research program of national interest: the Hood River Conservation Project. This well-documented effort showed that utilities can obtain very high levels of program participation in a community (80-90 percent). It tested high levels of weatherization that resulted in a final energy efficiency equivalent to the best performance of new homes constructed to then current building codes at an average cost of approximately \$4,400 per house. This compares with a current cost of \$2,600 per house in the regular weatherization program.

Existing Commercial:

BPA and its customer utilities began early to tap the large potential for conservation in the commercial sector. Programs ranging from commercial hot water efficiency improvements to comprehensive audit/incentive programs have resulted in over 5000 buildings being retrofitted. In addition, in order to understand the barriers to program penetration in this sector and build better capability to acquire these resources, BPA has also implemented a series of pilot programs. This has resulted in an estimated reduction in load growth of 55 MW, at a cost of approximately \$100 million.

Existing Industrial:

BPA experience in industrial retrofit programs has indicated that while industrial conservation is an inexpensive, reliable, and very large

resource, the idiosyncrasies of individual plants are such that efficiency improvements are very site-specific. Some technologies, such as efficient motors and variable speed drives, are generally applicable, but our experience with the first 50 plant retrofits reflects a need to provide almost one-on-one consumer assistance.

The most ambitious and successful program was targeted to a specific industry of great economic importance to the Region: the Aluminum Smelter Conservation/Modernization Program (Con/Mod). All eight regional smelters, representing 10 plants, have signed up for the Con/Mod Program. Aggregate energy savings achieved in the first year of the program exceed 40 MW with BPA expenditures of \$1.9 million. It is anticipated that the Con/Mod Program will result in 170 MW of energy savings by 1991. Although BPA will invest \$100 million over the 10-year period, it is estimated that aluminum companies will invest four times that amount.

New Residential and Commercial:

As part of PL96-501, Congress required the Northwest Power Planning Council to develop a set of construction standards that would be "regionally cost-effective and economically feasible to the consumer." Once these standards, called the Model Conservation Standards (MCS), were established, then the jurisdictions in the region were expected to adopt and enforce them for new electrically heated construction or major remodels involving electric heat. The Council could recommend, and BPA could implement, a surcharge on electricity rates to non-complying jurisdictions in the range of 10-50 percent.

By their nature, the standards proposed by the Council in its 1983 Plan were seen as pushing the limits of practical energy efficiency. Resistance by builders, utilities, political jurisdictions, and homebuyers was encountered. From 1984 to the present, BPA has implemented a series of innovative programs designed to establish the cost-effectiveness of the standards, overcome resistance, and encourage widespread integration of the MCS into new home construction without having to implement a surcharge. These programs included demonstration programs, support for code enforcement, technology development and transfer programs, and efficient housing training and marketing programs. BPA is currently involved in advancing construction practices in the region in both the residential and commercial sectors. In the last 3 years, over 7,000 homes have been built to meet the Model Conservation Standards. At a first cost of \$900 per unit, these residences use 40 percent less electricity for heating than current code. In addition, under pilot programs, BPA has helped construct 100 commercial buildings that exceed the Model Conservation Standards.

Conclusion

BPA views energy efficiency as a major resource. BPA has gone about planning and building capability to acquire the resource, and testing the resource in a deliberate and careful manner. Each conservation program has been evaluated to establish the size and reliability of conservation resources. With least cost planning solidly in place, BPA has conducted experiments to build capability and continued cost-effective acquisitions

in a time of a temporary power surplus. Eight years of experience has established a record which demonstrates that energy efficiency can be a major, reliable, and cost-effective resource.

I thank the Committee for the opportunity to present our experience and would be glad to address any questions you have.

Figure 1

OUTLINE OF BONNEVILLE PROGRAMS			
<u>Retrofit Residential</u>	<u>New Residential</u>	<u>Retrofit Commercial</u>	<u>New Commercial</u>
Pilot (1980)*	Res. Standards Demonstration Program (1984)	Hot Water (1980)	Energy Edge (1986)
Interim (1982)	Tacoma (1984)	Street and Area Lighting (1981)	Smart Design (1988)
Long Term (1984)		Institutional Bldgs. Program (1983)	
-Hood River (1983)	Res. Construction Demo. Prog. (1986)	Commercial Field Test (1983)	
Revised Long Term Program (1988)	Super Good Cents (1985)	Purchase of Energy Savings I & II (1983-4)	
	Early Adopters of MCS Codes (1985)	Commercial Incentives Pilot Program (1986)	
		Comm. Audit Prog. (1985)	
		Comm. Retrofit End Use Study (1988)	
<u>Industrial</u>	<u>Irrigation</u>	<u>Consumer</u>	
Sponsor Design (1984)	Pump Tests (1980)	Appliance Efficiency (1985)	
Industrial Test Pilot (1984)	Inspections (1980)	Solar & Heat Pump Market Test (1984)	
Conservation-Modernization (1987)	Retrofits (1983)	Solar and Heat Pump Performance (1984)	
Energy Savings Plan (1988)	Scheduling (1983)		

*Date indicates when the program started.

Senator WIRTH. Thank you, Ms. Hickey.
Mr. Robertson.

**STATEMENT OF WILLIAM D. ROBERTSON, VICE PRESIDENT OF
PLANNING AND PUBLIC AFFAIRS, PACIFIC POWER & LIGHT CO.**

Mr. ROBERTSON. Thank you, Senator Wirth.

I would like to take the time available to me to emphasize three or four aspects of the issues we have been talking about this morning to give you our perspective on them. As Ralph Cavanagh mentioned earlier and Sue Hickey has mentioned, we have been involved in conservation-related activities over the years. I will address that briefly, but along with it a couple of other points.

First, we believe it is vital to understand that the energy services industry, including the electric utility segment of it, is changing rapidly. It is a great deal more competitive today than it was a decade ago.

One result of that change is new uncertainty for electric utilities and others who are part of the energy services sector. It is more difficult than ever for us to forecast demand because we no longer monopolize major portions of our market. For that reason, we and others are scrambling to reduce costs and improve service simply to improve the odds we can hang onto our market share, a market share unfortunately we have taken too much for granted over the years.

That means we are and will continue to be cautious in our approach to programs that are likely to increase costs even if regulators agree in advance that the costs of certain programs can be passed along to customers because, regardless of what we and our regulators say to one another, what the market is telling is in too many cases is that rising costs mean loss of sales.

The good news is that the trend toward increased competitiveness forces in the direction of greater efficiency both in how we get and distribute our basic product and in how we encourage our customers to use it. The simple fact is satisfied customers are less likely to look for alternatives to our service, and customers whose costs are relatively low, whose use is efficient are likely to be more satisfied.

A second point we would like to emphasize is that potential for improved efficiency in the existing energy production and distribution system should not be overlooked as we search for ways to improve the overall efficiency of energy use. The recent merger of our company, Pacific Power, and Utah Power illustrates the point. As a result of that merger, two companies who faced the need to build or acquire resources in the next several years have been able to put off such requirements for the foreseeable future.

The reason is that because of the merger, we are able to take advantage of differences in the power systems and requirements of both companies. Utah Power's system is built to meet demand at peaks in the summer months while Pacific system's is geared to meet winter peaks. When the two are combined, both peaks can be met with capacity to spare. The effect of the combination is like adding a new 400 megawatt plant to our combined systems without

doing anything more than making modest improvement in the transmission interconnections between our two companies.

We are not, of course, recommending a wave of mergers as the solution problems, least of all global warming. We are, however, suggesting that efficiency can be improved to the extent that exchange arrangements can be facilitated.

A third point we would like to highlight relates to end-use efficiency or conservation as it is usually called. Pacific Power has had a great deal of experience with conservation programs. We believe we were the first utility in the country to begin treating conservation as a resource with our zero interest loan weatherization program in the 1970s. We were partners with Bonneville, as Sue said, in implementing the Hood River conservation project in the early 1980s, and we are involved in a wide array of program research and pilot testing of services to help our customers use energy more efficiently. At any given moment we have been 15 and 20 separate programs that are in one phase or another of implementation and testing.

Our experience has taught us a couple of things. First, we have found we have had better luck promoting conservation as part of a broad marketing effort than we have had prescribing it. We and others in our region have encountered significant difficulty in attempting to mandate through legislatures such things as model conservation standards. Too many oxes seem to get gored along the way.

On the other hand, when efficiency is packaged as one of several amenities that comes as part of the energy service we offer our customers, we found there is broad consumer interest in it. As a result, we have been working to build consumer demand for service that includes an energy efficiency component. Programs we have implemented to these ends have helped us retain existing customers while stabilizing future demand by improving consumer efficiency. And they have given us valuable experience with a source of supply if and when we need it.

In short, conservation and marketing have worked best when they have worked hand in hand. In our circumstances, the former would not work well without the latter because unless we can sell the resource that is acquired through conservation and energy efficiency programs, costs rise, sales fall and customers begin looking for new suppliers. That is an experience we lived through in the 1970s and early 1980s when new resource costs of other types drove prices upward. It is not an experience we plan to repeat.

From a regulatory standpoint, it is essential that the need for balance in these activities be understood. That is not always the case today. In many states activity that resembles any marketing, in effect, is penalized.

A fourth and final point I would like to make relates to alternative energy resource development. In our minds the question confronting us on the alternative development front is not whether such technologies will play a major role in the future. We believe they will. The question is how they will be applied and who will bring them to market.

As you know, much of the research and development work on these technologies is occurring outside of the electric utility indus-

try. A variety of energy service suppliers already are offering cogeneration to industrial and commercial consumers as an alternative to local utility service. We believe such developments are part of a trend that will continue to accelerate in the years ahead and we are working hard to determine how we might best play a constructive role in bringing alternative resources to market as part of our business.

To this end, we formed an integrated energy services subsidiary called ONSITE Energy to explore opportunities outside of the framework of our regulated utility operations. ONSITE applies both supply and demand technologies to increase end-use customers' competitiveness and productivity.

Among other things, ONSITE has learned significant opportunities for alternative resource development, as well as demand side management services, exist in overseas markets. To date, however, its ability to penetrate these markets has been restricted primarily because of the Public Utility Holding Company Act provisions which severely limit ownership of overseas generating and distribution assets, no matter how small they are, by U.S. utilities, their subsidiaries and other companies.

We think this restriction has special significance in the context of discussions about global warming because its overseas energy system development, as others have said today, that is expected to be the most significant contributor to growth and emission of greenhouse gases in the years to come. The interest we have seen in ONSITE services suggests to us there are opportunities to influence the evolution of developing energy systems that are significant enough to warrant some consideration of a narrow amendment to the act.

Thank you.

[The prepared statement of Mr. Robertson follows:]

PREPARED STATEMENT OF WILLIAM D. ROBERTSON
BEFORE THE SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
REGARDING A NATIONAL ENERGY POLICY
TO REDUCE GLOBAL WARMING

MARCH 14, 1989

Mr. Chairman and Members of the Committee:

My name is Bill Robertson. I am vice president of planning and public affairs for the Pacific Power & Light Company. Pacific Power is part of the energy services division of PacifiCorp. As you may know, we recently merged with the Utah Power & Light Company, which now joins us as an operating division of PacifiCorp.

Pacific Power serves some 670,000 customers in Oregon, Washington, Idaho, Montana, Wyoming and Northern California. Utah Power serves 523,00 customers in Utah, southeastern Idaho and southwestern Wyoming.

We appreciate the opportunity to express our views on developing a national policy to address global warming. It is a subject of great interest to us because 81 percent of Pacific Power and Utah Power energy requirements are met by coal-fired generation.

We have gathered preliminary estimates of the cost of reducing CO₂ emissions at some of our facilities. Based on current technology, which is not yet available on a large industrial scale, capital costs are in the neighborhood of about \$815/kW, with operating costs about 9 mills/kWh. This is almost double the cost of removing sulfur dioxide from emissions. Our estimates do not include the disposal cost of recovered CO₂, because a workable technology does not exist today. We can tell you, however, that the amount of recovered CO₂ would be substantial.

Uncertainties about global warming and the expense of retrofitting to address it, lead us to believe that a prudent strategy for meeting future energy needs is one that emphasizes:

- more efficient distribution of existing resources;
- development and delivery of conservation and related products and services that increase the efficiency of energy use; and
- accelerated development of alternative energy resources, both here and around the globe.

All of these approaches are already integral components of Pacific's business activities.

We also believe there is a growing need for flexibility in the way we produce, price, package and market our products and services, and in the way those activities are regulated.

THE CHANGING ENERGY SERVICES MARKETPLACE

In addressing these and related issues, we believe it is vital to understand that the energy services industry, including the electric utility business, is changing rapidly. That change is having a significant impact on how we approach our business, and on how we, as an industry, are likely to respond to public policy directives and regulatory initiatives.

The most important aspect of this change is increased competition, both from traditional and new suppliers of energy services.

A number of factors contribute to this change in circumstance. Key among them are the rising energy prices experienced in the late 1970s and early 1980s and development and diffusion of new energy production and control technologies made economical by those rising prices.

Whatever the reasons, a growing share of utility sales are "at risk" to competitors. That makes demand an increasingly uncertain element in our planning. We expect that uncertainty to grow as technology continues to provide all of our customers with a growing array of alternatives to meet their energy service needs.

The bottom line is that Pacific Power no longer views itself as a "natural monopoly" with an endless ability to pass prudently incurred costs along to customers. Growing portions of our marketplace simply are too volatile for such an approach.

We are working hard to adjust to this new fact of our business life by reducing costs, improving efficiency, and seeking new ways to improve, package and price the service we offer so that it better meets the needs of different customer groups.

As a general proposition, we believe utility regulation will require constant and fairly rapid adjustment in the years ahead if utilities are to deal successfully with these changing market dynamics.

MORE EFFICIENT USE OF EXISTING RESOURCES

A number of opportunities exist to use more efficiently the electric systems now in place. The recent merger of PacifiCorp and Utah Power is one illustration.

The merger combines together two companies whose service areas have distinctive characteristics. In particular, Utah Power's peak occurs in the summer, while Pacific

Power's area is winter-peaking. Integrating the two systems enables us to postpone indefinitely the need for additional generating resources.

Improved technology can also enhance efficiency. For example, modifications to transmission and distribution systems can reduce losses in transmission, now estimated to be up to 10 percent of production.

In another area, the environmental community, in its "Blueprint for the Environment" recommendations to the Bush Administration, called for expanded use of the federal hydropower system to substitute for existing oil and coal-fired generation. Utilities in the Pacific Northwest have been exploring opportunities with the Bonneville Power Administration for more efficient use of the power produced by the Columbia River system.

PACIFIC'S EXPERIENCE IN ENERGY EFFICIENCY

Pacific Power has been a leader in the delivery of conservation and energy efficiency-related services for over fifteen years. In the 1970s we were the first utility in the nation to begin treating conservation as a true resource alternative. We authored the nation's first conservation resource acquisition program by offering zero-interest loans to our customers for weatherizing their homes. We are continuing as an energy efficiency leader through program research and pilot testing of delivery of services to help customers use energy more efficiently.

Before describing some of those programs, I'd like to talk briefly about our experience with attempts to mandate energy efficiency.

As many of you know, the Northwest is home to a unique entity known as the Northwest Power Planning Council. The Council, created by the 1980 "Pacific Northwest Electric Power Planning and Conservation Act", is responsible for developing a least-cost electric energy plan for the region -- the states of Washington, Oregon, Idaho, and western Montana. In the least-cost energy plan, conservation is given top priority as a means of meeting new energy needs, followed by renewable resources.

The Council, in accordance with its mandate, and as part of its first energy plan, adopted Model Conservation Standards, (MCS), for new residential and commercial buildings. Model Conservation Standards are electric energy efficiency building codes. Since adoption of the first energy plan in 1983, the Council, Pacific, and others, have been working to place these standards in state building codes. While some progress has been made -- Washington and Oregon have upgraded their state building codes closer to the Council's standards -- a substantial gap remains between what the Council and others want and what states have been able to do.

Reasons for the lack of success are numerous. Homebuilders are concerned about measures that could force the price of new homes up; gas utilities and oil heat companies have fought attempts to apply the codes to homes that don't have electric

space heat; electric utilities have resisted initiatives that would place them at a disadvantage relative to competitors in the energy service marketplace.

Pacific's conclusion from this experience is that a better way exists to achieve significant gains in energy efficiency than by prescribing it; that is, by promoting it.

To this end, we recently launched a residential construction marketing program aimed at encouraging the construction of homes to the Council's standards – Pacific Plus. The program positions energy efficiency as one of several amenities that comes with the purchase of a Pacific Plus home, and backs the marketing effort with cash incentives.

Behind Pacific Plus is the realization that many consumers are not particularly attracted to energy efficiency by itself. But the added value of an energy efficient home – increased comfort, cleanliness, quiet – has great appeal. Our view is that consumer demand, not homebuilders, legislators, regulators, or utilities, will ensure that energy efficient homes are built, provided such homes offer the benefits consumers want.

Another illustration of the concept is our unique "Hassle Free" electric hot water heater replacement program. The goal with "Hassle Free" is to provide a high level of self funding energy service to our customers while also making dramatic gains in energy efficiency.

It works like this: for a small monthly charge, we guarantee to repair or replace customers' worn-out hot water heating equipment within 24 hours of when it stops working -- at no cost. The program enables us to require water heater efficiency, which exceeds federal standards and accelerates the diffusion of high efficiency equipment into the marketplace.

To date, 62,000 customers are participating, with more enrolling all the time. Because "Hassle Free" provides our customers with a valuable energy service, we are shaping the market for energy efficiency by driving consumer demand.

In short, attempts to mandate energy efficiency have been disappointing. But providing energy efficiency as a service to our customers had an excellent response.

Because of this, we are working to ensure that every major new use of electricity on our system incorporates high levels of efficiency. We are operating or designing incentive programs for all major categories of power consumption, from commercial buildings to water heaters to refrigerators. We also are capitalizing on all cost-effective opportunities to improve the efficiency of existing energy uses.

We should point out that we are not doing all these things to maximize the amount of conservation resource available to us today. At this time, we do not need additional resources. And acquiring them would simply increase our costs, prices and surplus.

We are delivering products and services which increase the efficiency of energy use and "conserve" because they:

- add to the appeal of our basic product and expand our line of marketable products and services;
- reduce the risk that customers will turn to other energy suppliers by improving their level of satisfaction with our service; and
- provide us a hedge against future resource uncertainty by giving us "hands on" experience in acquiring new and different types of conservation resources.

In sum, our energy efficiency and conservation-related activities have worked in combination with our marketing efforts to help stabilize both the demand and the supply outlook for our company.

But, in our circumstances, one would not work without the other because unless you can "sell" the resource that is acquired through conservation and energy efficiency programs, costs rise, sales fall and customers begin looking for new suppliers of energy services. That is an experience we lived through in the 1970s and early 1980s when new resource costs drove prices upward. It is not an experience we plan to repeat.

From a regulatory standpoint, it is essential that the need for balance in these activities be understood. That is not the case in many areas today, where any activity that resembles marketing is, in effect, penalized.

ALTERNATIVE ENERGY DEVELOPMENT

Development of alternative energy resources is a promising option in dealing with global warming and other environmental concerns. Great strides have been made in recent years in improving the efficiency of technologies such as photovoltaics, wind, fuel cells and small-scale cogeneration. Some of these resources - particularly cogeneration - already play a significant role in meeting energy needs.

To our minds, the question is not whether such technologies will play a major role, but how they will be applied in the future and who will bring them to market.

Much of the research and development work on these technologies is occurring outside of the electric utility industry. A variety of energy service suppliers already are offering cogeneration to industrial and commercial consumers as an alternative to local utility service. In some parts of the country, the natural gas industry is offering cogeneration to customers as part of its marketing program.

Pacific Power believes such developments are part of a trend that will continue to accelerate in the years ahead, as sophisticated energy management and control technology simplifies the operation of generation equipment.

While we do not need additional resources for the foreseeable future, we believe it is essential that we understand developing technologies so that we can assess their probable impact on our business and determine how we might play a constructive role in bringing them to market.

To this end, we have conducted a variety of pilot programs to test the feasibility of alternative technologies.

In addition, in 1986, we formed an integrated energy services subsidiary, ONSITE Energy, to explore opportunities outside of the framework of our regulated utility operations.

ONSITE applies both supply and demand technologies to increase its customers' productivity and competitiveness. Its primary focus is services to end users, as opposed to utilities. It also participates in development of some small, utility-oriented generation systems to the extent allowed by law.

We have found there is a great deal of interest in the services ONSITE offers. Sources that may be of particular interest in the context of global warming are energy users in remote areas and developing countries, where utility infrastructure is not well developed.

ONSITE believes significant opportunities for alternative resource development as well as demand side management, exist in overseas markets. To date, however, its ability to penetrate these markets have been restricted, primarily because of Public Utility Holding Company Act (PUHCA) provisions which severely limit ownership of overseas generating and distribution assets by U.S. utilities and other companies. In essence, ownership of assets defined by the act as utility property - no matter their size - makes the parent company of the owner/developer a holding company subject to the Act. Obtaining exemptions from PUHCA is possible, but the process is time consuming and the results revocable.

Such restrictions make it difficult for U.S. companies, and electric utilities in particular, to participate in development of new energy systems in those parts of the world where growth is likely to be most rapid and new contributions to the production of "greenhouse gases" most significant.

The interest we have seen in ONSITE's services suggests to us the opportunities to influence the evolution of developing energy systems are significant enough to warrant consideration of a narrow amendment to the Act.

CONCLUSION

At Pacific, our thinking is at an early stage in dealing with these issues. We are looking forward, however, to continued participation in the debates. One thing seems clear -- flexibility is key to managing an uncertain future. We need flexibility in packaging, pricing and marketing our product to compete in the highly uncertain, market-driven future we see developing.

We will need your continued leadership and assistance as we go down the road toward solving this problem.

Thank you.

Senator WIRTH. Thank you very much, Dr. Robertson. It is a very impressive combination, the two of you. Thank you very much.
Mr. Wiel.

**STATEMENT OF STEPHEN WIEL, COMMISSIONER, NEVADA
PUBLIC SERVICE COMMISSION**

Mr. WIEL. Thank you, Senator Wirth. For the record, I am Steve Wiel. I am a public service commissioner in the State of Nevada, and I chair NARUC's, the National Association of Regulatory Utility Commissioners, Committee on Energy Conservation. I am also a member of the board of directors of both The Alliance to Save Energy and the American Council for an Energy Efficient Economy. I am speaking today primarily on behalf of the Conservation Committee of NARUC. I will make several comments on behalf of NARUC as a whole.

I am here to applaud your efforts and to support S. 324.

In my written testimony, I have provided comments on 14 elements of S. 324 which support energy efficiency and renewable resources. I support all 14 of those elements. I provide comments, recommendations to change six of them. Five of those six recommendations are to simply do more of what you are proposing to do including, for example, in the energy efficiency funding to specifically acknowledge the least-cost utility program within the Department of Energy. The recommendations are all listed on pages 25 and 26 in summary form within my testimony.

One of the six recommendations we make, however, is to delete one section of the bill, and that is part of your section 313(b) that would substitute a provision in PURPA. It would remove section 210(b) and substitute a new 210(c) which would provide options for states to consider what is been called a no-losers test. Respectfully, I think that would be a mistake for you to include that because while it appears you are giving states an option, I think in fact what you will be doing by acknowledging that test would be to simply encourage its further consideration, and it should die a nice, quiet death.

But what I would like to do is take the time that I have available today to discuss the two elements of the bill which, in fact, most importantly affect state regulators, and those are the provisions in subtitle B of Title III of the bill that focus on utility companies.

You have heard already that there exists a huge reservoir of energy efficiency waiting to be tapped, enough to easily satisfy the 20 percent carbon dioxide reduction which you are seeking as a goal in your bill. I would put forward that there are two reasons why this huge reservoir exists today and isn't satisfied by the current private market in this country.

First of all, there exists a significant gap between the personal discount rates that we consumers use in making our investment decisions and the discount rate that is used by utility companies in making societal investments. And there is much published on this subject, the fact that there are third parties that do the purchasing, contractors that put in furnaces and not use them. There is a lack of availability of capital. There is a lack of information. There are many documented reasons, but the point is there is a signifi-

cant gap in the discount rates and that causes inefficient investment from a societal point of view.

Secondly, to the degree that in any one year there is such a gap, the rising prices in electricity over the last 19 years, since 1970, mean that every year there is a new higher level of efficiency worth purchasing. And year by year the gap widens between the currently wise level of efficiency and the embedded level of efficiency in our past purchases.

So, for these reasons, I think there is a large reservoir of energy efficiency to be tapped, and there are barriers that need to be overcome in order to tap them.

The primary point is that if we are going to tap this reservoir of energy efficiency, as all the witnesses today have suggested, the only way we can do it is to stimulate and help develop in this country a major energy services industry. Such development would have to be along the lines that PURPA in 1978 stimulated the cogeneration industry which since PURPA, in the decade since PURPA, has increased a hundred-fold. Back then there were on the order of 600 to 700 megawatts generated by cogeneration in small, independent power producers, and now it is 64,000 megawatts, approximately the same amount of energy that Mr. McCollam in recent speech has said is needed over the next decade in new capacity. Two-thirds of that has been from cogeneration.

This, by the way—the creation of the energy services industry I am talking about—would I believe go a long way toward satisfying the sensitivities that Senator Rockefeller spoke of earlier today when he was looking to see what kind of job creation this would develop. And I think it would be a plus for job development because, in fact, the energy services industry, as was alluded to earlier, is significantly more labor-intensive than the power plant industry which is one of the least labor-intensive industries that we have.

You call in your bill for a two-pronged approach toward creating this industry. First of all, recognizing that Mr. Cavanagh was right earlier when he said that 49 of the 50 states, in essence, penalize utility companies instead of rewarding utility companies for being successful at tapping that energy efficiency market, we recognize that as public service commissioners.

Within NARUC, the Energy Conservation Committee has been working on this problem and we are undertaking an effort within NARUC to stimulate states to change rulemaking procedures, rate-making procedures, to make least-cost planning and the subsequent investment in energy efficiency profitable. And the bill that you propose requiring states to report back in two years the status of their considerations would certainly be a strong stimulus which I support.

And secondly, by making a parallel effort for conservation and energy efficiency that you have already created within PURPA for cogeneration in independent power production, you would remove barriers which would allow, actually force, utility companies to stimulate private growth in the energy services industry.

So, we have a two-pronged approach. We are causing utility companies to step into that industry where there is a significant amount of talent and technical resources right now, and we are re-

quiring utility companies to allow, even encourage, other participants in that industry. These two steps alone I believe would go a long way toward achieving the goals you seek in carbon dioxide emission reduction.

I certainly agree with the comments made by you, Senator Wirth, and several others this morning saying that this is sound investment independent of the environmental benefits that we receive from the act. We certainly agree with that.

I would simply like to conclude by answering a question you asked an earlier panel. You asked what could the President do that the President isn't doing now. You received two answers which I wholeheartedly agree with. One, I think the Federal Government should set an example, and I didn't see any dissent when that was mentioned. I think the President also should take the global initiative.

But I see a third element that I think is important. We are calling for a national least-cost energy plan. It is important that that plan receive public comment, and I don't mean just perfunctorily collect comment along the way. I think that that plan should be the focus of a public and national debate. I think that the people preparing the plan should openly consider all comments received on that plan, and the President could focus national attention on the evolution and results of that plan, and I think that would help significantly.

Thank you.

[The prepared statement of Mr. Wiel follows:]

BEFORE THE
UNITED STATES SENATE
COMMITTEE ON ENERGY AND NATURAL RESOURCES

TESTIMONY

STEPHEN WIEL
COMMISSIONER
NEVADA PUBLIC SERVICE COMMISSION

ON BEHALF OF THE
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ON
GLOBAL WARMING AND S. 324

MARCH 14, 1989

National Association of Regulatory Utility Commissioners

Testimony of Commissioner Stephen Wiel
Nevada Public Service Commission

I. Introduction and Overview.

Good morning. My name is Stephen Wiel. I am a Public Service Commissioner in the State of Nevada. I chair the NARUC Committee on Energy Conservation, and I am a member the NARUC Executive Committee. I am also a member of the Board of Directors of both the Alliance to Save Energy and the American Council for an Energy Efficient for an Economy.

We may one day remember the summer of 1988 as the historic moment in which the people of this nation began to pay attention to the global climatic changes wrought by certain human activities to which the planet appears to be sensitive. If we may also remember 1989 as the year in which this nation, through its elected government, responded swiftly and surely to the awful challenge raised by this new awareness, the children who inherit our Earth may yet honor us, both for our wisdom and for our resolve. The National Energy Policy Act of 1989, S. 324, clearly acknowledges the global climate problem and implicates what is perhaps its principal source: too much burning of carbon fuels. The Act proposes a bold remedy: slow down the fast burn to four-fifths of its current rate. To achieve this goal, the Act builds a coherent set of policies and programs around a dominant central theme: get

more useful work out of all the fuel we burn.

The National Association of Regulatory Utility Commissioners has reached similar conclusions about the problem and its remedies. We therefore agree with the principal findings of the Act, and strongly support its broad purposes.

I am providing testimony addressing each section of S. 324. This testimony enthusiastically supports those provisions of the bill which promote increased energy efficiency. The testimony provides special attention to those provisions affecting utility companies and their regulators. It describes the opportunity you have to remove the barriers which keep this country from using energy in an economically sound and environmentally sensible way. It urges you to take advantage of that opportunity.

You have already heard from others that there exists a huge reservoir of untapped energy efficiency, large enough, in the abstract, to drastically reduce our current consumption. More practically and sensibly, it is large enough to avoid increased energy consumption for a decade or more. You have heard the two reasons how this large untapped reservoir has come to pass:

1. There exists a significant gap between the efficiency which consumers purchase and the societal optimum level. This occurs because there is a marked difference between the social discount rate at which our utilities make public investments and the personal discount rates at which each of their customers, namely all of us, choose

in our individual energy investment decisions. I may turn down the opportunity to invest an extra \$400.00 in my home's furnace to increase its efficiency from 80 percent to 90 percent because the saving in fuel cost doesn't pay for the extra expense within, say, three years. My decision then forces my utility company to make an investment in fuel and new power plants which is based on a full fifteen year recovery. Furthermore, it is likely that neither the utility company nor I will consider carbon dioxide emissions in making our decision. The result is the failure of our society to achieve optimal energy utilization.

2. Energy prices, after declining in both real and nominal terms for the entire century up until 1970, have, in contrast, been increasing for the almost two decades since that time. As prices increase, so does the level of energy efficiency which is economically justified. And, the longer the price of energy continues to rise, the greater becomes the gap between the current economically optimum level of efficiency and the embedded level of efficiency created by two decades of purchases at lower levels.

In order to exploit the opportunities for major improvements in energy efficiency, this country must develop a major energy services industry. The rudiment of such an industry already exists. Consulting engineers, contractors and utility companies offer services to utility company customers to help them use energy more efficiently. But this fledgling industry is in a similar situation to that of the cogeneration industry prior to PURPA, a decade ago. PURPA removed the barriers to the use of cogeneration. The cogeneration industry multiplied a hundred-fold in a decade. It's time now to remove the barriers in the energy services industry to let it follow a path parallel to the cogeneration path.

A two-pronged attack on these barriers to the energy services

industry is needed; and S. 324 provides both prongs.

Utility companies are the logical focus. Utility companies can facilitate the development of a private energy services industry by subsidizing it with a portion of the societal benefits which such an industry would provide. Likewise, utility companies can expand their direct participation in that industry.

The private energy services industry is currently hindered by the nature of their current clients: the homeowners and businessmen who consume gas and electricity. As pointed out earlier, this group of people has much higher investment discount rates than does society overall. This group is preoccupied with their primary business and personal interests and has little time to attend to shopping for energy services.

This group can generally be classified as a widespread and diverse amalgamation of small clients, a difficult challenge for any industry. These clients have one thing in common, they are all customers of utility companies, and therein lies the salvation. Utility companies can become the liaison between energy service companies and the utility customers, and, where appropriate, can even become the client for the energy service company. Congress needs only to pass Sections 312 and 313 of this Act, and the FERC and State commissions will see that utility companies purchase conservation and load management in a similar manner to the way

they now purchase cogeneration and independent power from qualifying facilities under PURPA.

Utility companies should also be encouraged to participate directly in the energy services industry. They are currently hindered by regulatory ratemaking practices which prevent them from making a profit from this activity. Current ratemaking formulas for gas and electric utilities in all States allow utility companies to profit only from capital investments and, in most States, from finding productive new uses of gas and electricity. The NARUC Conservation Committee is currently encouraging State commissions to modify their ratemaking formulas to also allow utilities to profit from providing energy services to their customers. Section 311 of this Act which requires State commissions to analyze and address this issue will greatly facilitate this effort.

All of S. 324's provisions to increase energy efficiency would be worthwhile as sound economic investment. The investments in energy efficiency addressed in this Act will in the long run more than pay for themselves. The environmental benefits which accompany this increased energy efficiency may be considered a free bonus, making the Act doubly worthwhile.

II. Comments.

A. FINDINGS AND PURPOSES.

NARUC enthusiastically endorses the Findings and Purposes of S. 324 that address energy efficiency and renewable energy. In 1984, NARUC adopted a resolution on national energy goals, which urged the government of the United States to:

assure adequate and reliable energy supplies by using resources in the most efficient manner...promote conservation...and encourage development of least cost system plans for major gas and electric utilities...[1]

NARUC in 1988 passed a resolution calling upon the Congress to:

swiftly enact legislation designed to improve the efficiency of the nation's use of its energy resources and reduce emissions of the nation's carbon compounds and to assist other nations in doing the same...[2]

Just two weeks ago, the NARUC Executive Committee renewed this commitment by passing another resolution supporting:

a national policy on global warming that is consistent with efforts to develop alternative energy sources and more efficient use of energy through conservation...[3]

Clearly, NARUC is firmly committed to the principles expressed in this bill. We especially support Section 2(a)(5), which finds that policies "must be designed to reduce carbon dioxide and trace

gas generation including reduction in the combustion of fossil fuels through energy efficiency, fuel switching, and conservation;..." We agree completely with the finding in Section 2(a)(6) that improved energy efficiency "can make the largest and least costly contribution to reducing carbon dioxide and trace gas production and reliance on imported oil." We therefore endorse wholeheartedly the finding of the proposed Act that improved energy efficiency should be at the center of our national efforts to reduce combustion of fossil fuels. We strongly urge the Congress to enact laws such as the one proposed here which are designed to cause major improvements in the nation's energy efficiency.

Section 3 establishes as national goals (a) a 20 percent reduction from 1988 levels of carbon dioxide produced nationwide by the year 2000; and (b) establishment of an International Global Agreement on the Atmosphere by 1992. We endorse these goals. A 20 percent reduction may seem politically ambitious, yet relative to the current global imbalance, it is a modest goal. The atmospheric concentration of carbon dioxide has grown markedly during the industrial era. If this growth is driving the global climate to instability, then halting this growth would be a rational response. To do so, we would need to reduce carbon dioxide output worldwide to the level which plants can absorb. Annual global production of carbon dioxide currently exceeds its biological demand in plant life by some 50 percent.[4] Simple arithmetic tells us that to rectify a 50 percent imbalance, with

no decrease in current carbon dioxide recycling by land and sea plants, production would have to be reduced by 33 percent. Therefore, a 20 percent reduction from current levels, even if achieved globally, would not halt the growth in atmospheric concentration, even at the higher level which will have been reached by the year 2000. Since there is some evidence that bringing carbon dioxide into global balance by 2000 would end the global warming trend within a few years thereafter,[5] a goal of a one-third reduction would at least offer a counsel of some hope. While a goal of 20 percent by 2000 may thus prove to have been too modest, it is a vital first step which we strongly support.

While slowing down the fast burn to four-fourths of its current level may seem a bold goal, and the two-thirds level even more so, both are achievable. The arithmetic of energy efficiency is often startling. You can replace a single 75-watt incandescent light bulb with a 20-watt compact screw-in fluorescent that gives just as much light, yet saves more than 70 percent of the 750 kilowatt-hours of electricity that would otherwise be used over its lifetime. The Osage, Iowa, municipal electric utility estimates that the 600 bulbs it has given to its customers will save energy equal to that generated by burning 120 tons of coal.[6] Each compact fluorescent lamp can be thought of as an energy resource equivalent to 400 pounds of coal. This is just one example of the vast opportunities to use energy more wisely which Dr. Arthur Rosenfield described in his testimony earlier this morning.

B. LEAST-COST NATIONAL ENERGY PLAN - TITLE I.

NARUC supports the requirement in Title I that Federal agencies jointly develop within 18 months a Least-Cost National Energy Plan, with all the elements specified in the Bill.

The least-cost planning process proposed here for the nation's energy resources closely reflects a parallel process in the planning and regulation of electric utilities already in effect in a number of States.[7] The Act defines "energy resources" to include efficiency improvements as well as additional energy supply. An energy resource is "cost-effective" if it will meet energy needs at lower estimated cost than that of the least-cost alternative plan. With help from their State regulators, a number of electric utilities in recent years have approached energy resource planning in just this way, weighing in the same scale with new power supply options a variety of utility-sponsored efficiency improvements on the customer's side of the electric meter. Recognizing the merit and promise of this approach, NARUC at its 1984 annual convention adopted a series of resolutions endorsing these planning principles. The Association urged the Federal government to:

Encourage development of least cost system plans for major gas and electric utilities in order to meet energy needs over the coming decades, which plans shall include the following: (1) conservation, (2) renewable resources, (3) use of waste heat or high fuel conversion efficiency, and (4) all other resources; and,

Concentrate additional Federal efforts on strengthening the Department of Energy's ability to gather data, provide coordination and provide assistance to States and the public; on establishing national appliance efficiency standards; on requiring increased thermal efficiency in buildings; and on establishing energy efficiency in transportation;...[8]

Parallel resolutions found that electric and gas utilities should view conservation "as an alternative to new supply options." These resolutions urged both State and Federal agencies to weigh the need for new power supply on the basis of a least-cost system plan, and urged the States to require development of such plans.[9]

Drawing on the success of electric system least-cost planning in a number of States, the NARUC has formally and repeatedly endorsed the broader application of those principles during the last five years. For example, since 1974, California has relied almost entirely on cogeneration and energy efficiency improvements to meet growing electricity needs, thus offsetting the need for seven or eight new power plants. Likewise, since 1978, least-cost planning in the Pacific Northwest has offset the need for 1300 megawatts of new power generation.

Federal policies and programs which have been tested and proved in the political laboratory of the States are surely among the most likely to succeed. We believe it is none too soon for the national government to build on this experience by developing and using a Least-Cost National Energy Plan, as proposed by Title I of

the Act. To expedite this process, it may be useful for the Act to also require the FERC to practice least-cost planning, and to produce a new National Power Survey focusing on ways to alleviate global warming, as proposed in H.R. 1078, Sections 211 and 212.

Title I(a)(3) would include in "system costs" of an energy resource all of its direct production and distribution costs over its effective life, including waste disposal costs and projected fuel costs, along with...such quantifiable environmental and national security costs and benefits as the Secretary and the Administrator determine are directly attributable to such resources.

Including such costs is both correct in terms of economic theory and difficult in its practical application. By limiting their inclusion to those costs which are both "quantifiable" and "directly attributable," the Act produces a workable definition. Recognizing that such costs may deserve consideration even when they are not readily quantified, and that meeting energy demand through efficiency improvements typically entails much smaller environmental costs than meeting the same demand with increased combustion or other power supply, Title I(a)(4) in effect gives conservation resources a ten percent cost-effectiveness bonus relative to other resources. Here, the Act follows the lead of the Northwest Power Planning Council, which gives a similar ten percent credit to conservation options.[10] These two provisions,

in combination, will enable the Plan to reflect environmental costs in a reasonable manner.

In summary, Title I of the Act creates a clear and coherent framework of Federal policy for achieving, in the most cost-effective way, the desired 20 percent improvement from today's levels of carbon dioxide production nationwide. The planning process defined in Title I would build on the successful experience of least-cost electric resource planning in a number of States. Its principles agree closely with those adopted by NARUC during the last five years. We urge unequivocally the prompt enactment of Title I.

C. ENERGY EFFICIENCY TARGET - TITLE III, Subtitle A, Section 301.

We support the provision of Section 301(b) which requires the Secretary of Energy to identify efficiency measures in amounts sufficient, when taken together, to reduce national energy use per unit of national product by two to four percent per year. This requirement will ensure that efficiency measures become a major section on the menu of resource options in front of energy planners, rather than a mere token element. If real GNP continues to grow at the annual rates typical of the current decade (2.9 percent per year, 1980-1988), annual efficiency gains in the two to four percent range would offset the growth in GNP, so that total

national energy use would remain approximately stable. Averaging over a decade or so, a similar offset of GNP growth by rising energy efficiency happened between the early 1970's and the mid-1980's, in substantial part as a result of Federal fuel economy standards and other efficiency programs.

To regain this balance by renewing the vigor of Federal efforts is certainly a desirable goal, but it appears quite modest relative to both the current global need and the overall goal of this Act, which call for major reductions, not just a levelling off. To achieve a 20 percent reduction by 2000, carbon combustion would need to decline by 1.8 percent in each of the 12 years between 1988 and 2000. If the National Energy Policy Act of 1989 were to become law before July, it would still be the end of 1990 before the Congress would see its first Least-Cost National Energy Plan, leaving 10 years, at most, to achieve the 20 percent reduction. Even if there were no significant increase in carbon combustion between 1988 and 1990, the annual reduction thereafter would have to be at least 2.2 percent.

Furthermore, since humans do not have perfect foresight, any plan is likely to contain elements that will not be realized. We need annual efficiency improvements of roughly 2.9 percent just to offset growth. We need another 2.2 percent to reduce carbon emissions, and we need a contingency to assure we achieve our goals. With energy efficiency at the center of the policy

strategies set forth in this Act, we believe there is a need to identify efficiency gains which total well in excess of four percent per year, rather than the "hold the line" level of two to four percent required under Section 301(b).

D. ENERGY EFFICIENCY R & D - TITLE III, Subtitle A, Sections 302-304.

NARUC supports increased appropriations for new and ongoing energy efficiency research, development, and demonstration projects, including joint ventures for commercial demonstration of energy efficiency technologies, and five regional centers for research and development to improve the efficiency of energy-intensive industrial processes. The NARUC explicitly recognized the value of these programs in a 1986 resolution, which found that:

a vigorous conservation research program must be given a high priority.[11]

Since then, we have testified half a dozen times before Congress in support of increased funding for conservation and renewable energy research and development. We are pleased to see the increased overall level of activity and funding for these important projects, but recommend that funds be authorized at the higher levels shown in H.R. 1078, Section 201.

We would further urge that the Department's valuable existing program in support of Least-Cost Utility Planning by the State regulatory commissions be explicitly authorized, as it is in H.R. 1078, Sections 208 and 209. An important purpose of the LCUP program is to facilitate the spread of least-cost planning throughout the U.S. and to analyze regulatory reforms designed to make least-cost planning more profitable, which is also the explicit goal of Subtitle B, Section 311 of this Act, discussed below.

E. FEDERAL BUILDINGS - TITLE III, Subtitle A, Section 305.

As a major energy user with wide public exposure, the public sector offers important opportunities, both for gaining substantial efficiency improvements and demonstrating these results to the wider public. We believe this Section of S. 324 is too modest, as it is limited to a study of the potential for energy savings in Federal buildings, with \$2.5 million authorized for the purpose. The cost-effectiveness of building efficiency improvements justifies a more ambitious effort, perhaps closer to that envisioned by H.R. 1078, Section 204, which mandates a 25 percent improvement by 1995 and 40 percent by 2000. To achieve these goals, we recommend creating incentives to implement all efficiency measures for Federal buildings that are found to be cost-effective, authorizing \$250 to 500 million per year.

F. HOME ENERGY EFFICIENCY RATINGS - TITLE III, Subtitle A,
Section 307.

Section 307 of the Act would result in Federal guidelines for State regulations requiring residential efficiency ratings. Energy efficiency labels on homes are as important and worthwhile as they are on cars and appliances. This is a vital program which requires Congressional attention.

We are aware that a voluntary approach to home energy efficiency labels has been proposed by H.R. 1078, which we feel may be more workable. In either case, Federal participation is needed to demonstrate commitment to the concept on a national level, aid in public education, help overcome barriers in the mortgage process, provide funding for the administration of State or local rating programs, and establish uniform rating methods and format. For national implementation, we are convinced that legislation and sufficient appropriations are needed for:

- (1) technical development; (2) setting up infrastructure;
- (3) providing initial training for energy inspectors and the shelter industry; (4) public education, and (5)
- policy changes in lending guidelines to facilitate use of the energy rating system and estimated energy costs at time of sale.

We base these conclusions in part on the success of a pilot program in Washington[12] and the receptiveness of the home mortgage industry to the proposal.[13] We urge the Federal

government to fund a home energy efficiency rating program and provide initial oversight, letting the shelter industry administer the rating system over the long run.

G. STANDARDS AND LABELS FOR LAMPS AND WINDOWS - TITLE III, Subtitle A, Sections 308-310.

NARUC supports Sections 308, 309 and 310 of the Act, which add lighting and windows to the list of appliances for which energy efficiency labels are required. In a 1986 resolution, the NARUC found that appliance energy conservation standards:

"are one of the most cost effective means of achieving energy efficiency" and urged the Congress to set such standards.[14]

We strongly support the prescription of energy efficiency standards for lamps provided in Section 308(c)(2). We note that H.R. 1078 at Section 206 also sets clear efficiency standards for incandescent and fluorescent lamps, while the language in S. 324 is less specific on this point. We urge the adoption of Federal efficiency standards for lamps. We also urge the adoption of Federal efficiency standards for windows and support increased stringency of all appliance standards to achieve full least-cost effectiveness over the useful life of the appliance.

H. ENERGY SERVICES BY UTILITY COMPANIES - TITLE III, Subtitle B, Section 311.

Section 311 would require State regulatory agencies to conduct proceedings with public hearings that consider ways to design electric and gas rates so as to reward successful least-cost planning with higher utility profits. This is one of the most important provisions of the Act. Least-cost planning seeks to minimize the total cost to society of providing its energy services. A utility's least-cost plan should be its most profitable plan, and under current practices, it is not. The mismatch under current regulatory practice between this social objective and each utility's obligation to its stockholders has become a matter of major regulatory concern. If the resources of the utility industry are to be seriously applied to achieving the goals of this Act, we must rectify this situation.

In a policy statement adopted last summer by unanimous vote, the NARUC Committee on Energy Conservation found that, because utility programs which increase energy efficiency reduce sales and therefore reduce profit:

[the] profit motive generally encourages utilities to invest in supply-side resources even when demand-side alternatives are clearly identified in its resource plan as being the least-cost resource.

To remedy this mismatch, the Committee urged State commissions to:

adopt appropriate mechanisms to compensate a utility for

earnings lost through the successful implementation of demand-side programs which are part of a least-cost plan and seek to make the least-cost plan a utility's most profitable resource plan.[15]

Finding ways to conform utility profit incentives with least-cost planning principles is currently the top priority of the NARUC Energy Conservation Committee. To date, very few State commissions have considered revising ratemaking practices along the lines recommended in this policy statement. California had previously adopted a ratemaking mechanism which achieves a portion of the standard set forth in the Act. Maine has begun a proceeding with a standard equivalent to that in the Act and the policy statement. NARUC's Energy Conservation Committee has identified several ratemaking mechanisms which could be used to allow utilities to profit from providing energy services to its customers. Federal legislation requiring the States to at least consider such ratemaking changes within two years would overcome much inertia, save valuable time, and could well result in very substantial improvements in the nation's end-use energy efficiency. Accordingly, the requirement in Section 311 requiring State regulatory agencies to consider ways to reward successful least-cost planning has our strong and unequivocal support. We urge its prompt enactment.

- I. ENERGY SERVICES BY NON-UTILITY COMPANIES - TITLE III, Subtitle B, Section 312 and 313.

Among the laws affecting electric utilities, the Public Utility Regulatory Policies Act of 1978 (PURPA) has proved to be one of the most significant and successful ever enacted. By rationalizing the design of electric rates and requiring utilities to purchase power from outside sources when its price is lower than utility costs, PURPA is dramatically changing the structure of the nation's electric power supply and lowering its overall cost. We urge Congress to extend PURPA's least-cost power supply logic to the acquisition of energy efficiency resources on the customer's side of the meter.

It is worth building on the remarkably successful experience with alternative power supply that began a decade ago with the wise enactment of PURPA. Sections 312 and 313 of the Act would extend that same least-cost logic to the acquisition of energy efficiency resources. Defining "qualifying conservation entity" in terms parallel to "qualifying cogenerator," the amended PURPA would require utilities to purchase conservation in much the same way that it now requires power supply purchases.

We have seen a dramatic response by non-utility investors to the opportunity and challenge afforded by PURPA for the development of alternative sources of electric power supply. Through the end of 1987, a total of 64,398 megawatts of PURPA qualifying generating capacity was on file with the Federal Energy Regulatory Commission (FERC). Eighty-one percent of this filed capacity investment has

been committed since the end of 1983, when the U. S. Supreme Court upheld the constitutionality of PURPA, and 69 percent represented true cogeneration.[16]

While these capacity figures are impressive, they tell only a part of the story. The rest of the story involves the timing and magnitude of the investment dollars involved to achieve the generating capacity on file with the FERC. The investment timing can best be described by noting that it has occurred during a period when classic utility capital spending has fallen off sharply because of various industry-specific factors. The investment magnitude associated with the 64,000 megawatts of capacity on file at the FERC probably exceeds \$100 billion. One can only guess how much larger that investment would have to have been had that same capacity been supplied by regulated utility companies.

The propitious advent of independent power producers in response to PURPA guidelines has allowed the electric power industry to avail itself of firm generation capacity to meet system demand while avoiding the potential risk associated with garnering the necessary return on in-house investment. We believe that the conditions are ripe for similarly dramatic developments in energy efficiency. Passage of Sections 312 and 313 will facilitate the development of an energy services industry of sufficient size to achieve the goals of this Act.

In a 1988 resolution, the NARUC Energy Conservation Committee urged the FERC:

to encourage States to include conservation and demand side measures on an equal basis with supply side sources in State bidding systems.[17]

In Maine, a pilot program allowing a utility to solicit conservation bids in parallel with its request for power supply drew a strong response. The utility's ranking system gave high marks to the proposals for efficiency investments. Several of these proposals have recently resulted in substantial contracts, both with industrial customers and with third-party energy service companies focusing on efficiency gains in homes and commercial establishments.[18] This section of the Act will plant the seeds for many more such programs.

The PURPA revisions proposed in this Act create a direct and effective way to approach the economic goal of least-cost planning. While we strongly support the enactment of Sections 312 and 313 of the Act, we strongly object to the language in Section 313(b) which provides for a new Section 210(c)(3) in PURPA. The first sentence prohibiting discrimination is certainly appropriate. The remainder which constrains ratemaking is inappropriate for generation and conservation. If it were adopted, substantial amounts of cost-effective conservation would likely be ruled out by any States or nonregulated utilities that chose the second (and lower) of the

two rate options for conservation purchases under the amended PURPA.

J. STATE ENERGY CONSERVATION PROGRAM - TITLE V

We are pleased to see and we support the increased funding request for State energy planning, for the Schools and Hospitals program, and for Weatherization Assistance called for in Title V of the Act. NARUC believes there are national energy imperatives which are appropriately addressed at the State level, and that State energy policies:

should be approached with renewed vigor in their development and implementation.[19]

We reaffirm here our past support of the valuable work carried out by the State and Local Energy Assistance Programs.[20]

K. RENEWABLE ENERGY - TITLE VI

Renewable energy sources offer important opportunities to reduce the overall cost of providing energy services and contribute to reaching the Act's goal of carbon dioxide control. As a general principle, research and development funding should be directed at those resources which offer the greatest promise of cost-effectiveness. We support increased funding for renewable

energy programs.

L. NATURAL GAS - TITLE X, Sections 1001 - 1005

NARUC has identified the development and application of natural gas vehicles as an important means to reducing the nation's air pollution.[21],[22] They also offer the potential for reducing the amount of carbon dioxide emitted. NARUC supports increased funding for natural gas vehicles research, development, and commercialisation.

M. URBAN FORESTRY - TITLE XI, Section 1103.

As you heard earlier this morning, urban trees appear to provide a highly cost-effective means for reducing air conditioning loads. Section 1103 of S. 324 is an important step but provides only for an 18-month study of the potential benefits of urban forestry. We urge the funding of a significant Federal program in urban forestation, as proposed in H.R. 1078, Sections 831 and 832.

N. ENERGY EFFICIENCY AND LEAST-COST PLANNING DEVELOPMENT ASSISTANCE - TITLE XIII, Sections 1304-1307 and TITLE XIV, Section 1407.

We support the adoption of Sections 1304 - 1307 and Section 1407 of the Act, which would help other countries to follow the example this nation will be setting if the earlier sections of the

Act are adopted. Clearly, all citizens of planet Earth share a common interest in achieving the goals of this landmark legislation.

III. Summary and Conclusion

The National Energy Policy Act of 1989, S. 324, and its close cousin in the House, H.R. 1078, have put in motion a landmark initiative by the Congress of the United States. In this effort, the Congress has looked bravely in the eye of a truly global crisis. It has proposed a bold remedy: slow down the burning of carbon fuels to four-fifths of its current rate by getting more useful work out of all the fuel we burn. The legislation would remove many barriers which keep the country from using energy in an economically sound and environmentally sensible way.

Building on the remarkably successful experience with alternative power supply that began a decade ago with PURPA, it would spur the parallel development of an energy services industry to further achieve the same least-cost objectives. It would extend the principles and practice of electric system least-cost planning, already tested and proven sound in a number of States, to all of the nation's energy resources.

In summary, the preceding sections of this testimony:

- 1) endorse the Findings and Purposes regarding energy

efficiency and renewable energy; 2) support Title I requiring a Least-Cost National Energy Plan and suggest also requiring FERC to practice least-cost planning and produce a National Power Survey; 3) support Title III, Section 301(b) calling for 2-4 percent reduction in energy use per unit of GNP but suggest the need to identify gains well in excess of the 2-4 percent range; 4) support Title III, Sections 302, 303, 304 increasing the appropriations for new and ongoing energy efficiency research, development, and demonstration and recommend even higher levels as proposed in H.R. 1078 and also recommend explicit authorization for the Least-Cost Utility Planning Project as proposed in H.R. 1078; 5) recommend that Title III Section 305 authorize \$250 to \$500 million per year to implement cost-effective efficiency improvement in Federal buildings; 6) support Title III Section 307 establishing a national home energy efficiency rating system; 7) support Title III Sections 308/309/310 establishing labels for lamps and windows and establishing standards for lamps and also urge establishing standards for windows and increasing stringency for all appliance standards; 8) support Title III Section 311 requiring State regulatory agencies to consider ways to reward successful least-cost planning; 9) support Title III Sections 312 and 313 which extend PURPA's least-cost supply logic to the acquisition of energy efficiency resources but strongly object to new PURPA Section 210(c)(3); 10) support Title V increasing funding for State Energy Conservation Programs; 11) support Title VI increasing funding for Renewable Energy; 12) support Title X Sections 1001 through 1005 increasing funding for natural gas vehicles research, development and commercialization; 13) support Title XI conducting an eighteen month study as an important step but urge funding for urban forestation as proposed in H.R. 1078; 14) support Title XIII Section 1304 through 1307 and Title XIV Section 1407 helping other countries to follow the example set by the United States.

The Congress has here set forth on what it might have seen as a sea of despair, but instead has emerged with a counsel of hope. This legislation has our overall support, and we hope it has yours.

March 14, 1989

ENDNOTES

1. NARUC Convention Resolution No. 5, "Resolution Supporting the Adoption of National Energy Goals," Adopted November 1984. (Attachment 1)
2. "Resolution on Global Warming," Adopted by the 1988 NARUC Annual Convention, November 2, 1988. (Attachment 2)
3. NARUC, "Resolution On a National Energy Policy Regarding Global Warming," Adopted by the NARUC Executive Committee on March 1, 1989. (Attachment 3)
4. Hansen, James E., et al, "Global Climate Changes as Forecast by Goddard Institute for Space Studies Three-Dimensional Model," Journal of Geophysical Research, forthcoming.
5. *ibid.*, "Scenario C."
6. Canine, Craig, "Generating Negawatts. The Way to Power the Nation's Future Is to Conserve the Energy We Are Already Producing," Harrowsmith, March/April 1989.
7. Electric Power Research Institute, Status of Least-Cost Planning in the United States, EPRI EM-6133, December 1988.
8. NARUC Convention Resolution No. 5, Adopted November, 1984. (Attachment 1)
9. NARUC Convention Resolutions No. 6 and 7, Adopted November, 1984. (Attachments 4 and 5)
10. Also, the Wisconsin Public Service Commission has just authorized a 15 percent planning credit for energy resource options that do not involve combustion. See its Advance Planning Order, Docket 05-EP-5.
11. "Resolution in Support of Federal Research on Energy Conservation," Convention Floor Resolution No. 3, Adopted November 19, 1986. (Attachment 6)
12. Joint Center for Housing Studies of the Massachusetts Institute of Technology and Harvard University, Summary of 1986 study, "The Effect of the Shelter Industry Energy Rated Homes (TM) System on Homeownership." (Attachment 7)
13. Levy, Gerald J., "Home Financiers Need Their Own Energy Rating System," Outlook of the Federal Home Loan Bank System, January/February 1987. (Attachment 8)

14. "Resolution on Appliance Standards," Convention Floor Resolution No. 6, Adopted November 19, 1986. (Attachment 9)
15. "Statement of Position of the NARUC Energy Conservation Committee on Least-Cost Planning Profitability," Adopted unanimously by the Committee on Energy Conservation on July 26, 1988. (Attachment 10)
16. Investor Responsibility Research Center; Generating Energy Alternatives, 1987 Edition, p. 37; as updated by IRRC through December 31, 1987.
17. Conservation Committee Resolution on FERC's PURPA Initiatives, Adopted March 2, 1988. (Attachment 12)
18. Central Maine Power Company, News Releases dated September 23, 1988 and February 14, 1989. (Attachment 13)
19. NARUC Convention Resolution No. 6, "Adoption of State Energy Goals," Adopted November, 1984. (Attachment 4)
20. Convention Floor Resolution No. 4, "Resolution on State and Local Energy Assistance Programs," Adopted November 19, 1986. (Attachment 14)
21. NARUC, "Resolution Supporting the Development and Use of Compressed Natural Gas Vehicles," Adopted July 28, 1988. (Attachment 15)
22. NARUC, "Resolution on Natural Gas Vehicles (NGVs)", Adopted by the Executive Committee on March 1, 1989. (Attachment 16)

ATTACHMENTS

1. NARUC Resolution Supporting the Adoption of National Energy Goals.
2. NARUC Resolution on Global Warming.
3. NARUC Resolution on a National Energy Policy Regarding Global Warming.
4. NARUC Convention Resolution No. 6.
5. NARUC Convention Resolution No. 7.
6. NARUC Resolution in Support of Federal Research on Energy Conservation.
7. Summary of home energy rating study by Joint Center for Housing Studies.
8. Article, "Home Financiers Need Their Own Energy Rating System."
9. NARUC Resolution on Appliance Standards.
10. NARUC statement on Least-Cost Planning Profitability.
11. Table of FERC-filed qualified facility capacity.
12. NARUC Conservation Committee Resolution on FERC's PURPA Initiatives.
13. News releases, Central Maine Power Company.
14. NARUC Resolution on State and Local Energy Assistance Programs.
15. NARUC Resolution Supporting...Natural Gas Vehicles.
16. NARUC Resolution on Natural Gas Vehicles (NGVs).

NARUC Convention Resolution No. 5

Resolution Supporting the Adoption of National Energy Goals

WHEREAS, There are national imperatives which require renewed vigor in the development and implementation of national energy policy; and

WHEREAS, The Nation continues to be dependent upon petroleum and other non-renewable resources as energy sources; and

WHEREAS, Existing national and international energy policies and conditions do not preclude the recurrence of serious problems arising from this dependence; and

WHEREAS, The increase in energy prices has a major adverse impact on the Nation's citizens and its economy; and

WHEREAS, Conventional sources of energy are subject to constraints involving supply, transportation, cost, environmental, health and safety considerations; and

WHEREAS, The Nation must devise strategies by which to address these problems including, but not limited to strategies to assure adequate, efficient, reliable energy supply and to avoid unnecessary and wasteful consumption; and

WHEREAS, Cost effective energy conservation measures can address such issues appropriately; now, therefore, be it

RESOLVED, That the National Association of Regulatory Utility Commissioners, assembled in its Ninety-sixth Annual Convention in Los Angeles, California, adopts the following goals and urges the government of the United States to find it in the interest of the nation to:

I. Assure adequate and reliable energy supply by using resources in the most efficient manner, by replacing energy resources vulnerable to interruption due to circumstance beyond the nation's control with those less vulnerable, and by encouraging the development and utilization of renewable resources;

II. Define conservation in terms of both avoidance of unnecessary and wasteful consumption and in terms of economic efficiency;

III. Promote conservation by encouraging consultative participation of states, local governments, consumers, energy companies, and the public at large in developing, implementing and updating plans and programs related to energy resource conservation and development;

IV. Improve utility conservation programs by raising consumer awareness to the benefits of conservation, by increasing consumer participation and by requiring utilities to develop programs to achieve implementation of audit recommendations;

V. Encourage development of least cost system plans for major gas and electric utilities in order to meet energy needs over the coming decades, which plans shall include the following: (1) conservation, (2) renewable resources, (3) use of waste heat or high fuel conversion efficiency and (4) all other resources;

VI. Concentrate additional federal efforts on strengthening the Department of Energy's ability to gather data, provide coordination and provide assistance to states and the public; on establishing national appliance efficiency standards; on requiring increased thermal efficiency in buildings; and on establishing energy efficiency in transportation; and

VII. Provide for the essential energy needs of the disadvantaged by providing utility incentives for the development of conservation and audit services, by providing increased permanent weatherization services for low income households, and by eliminating financial barriers to conservation improvements for the needy through loan or grant programs.

Sponsored by the Ad Hoc Committee on Energy Conservation

Adopted November 1984

ATTACHMENT 2

Resolution on Global Warming

WHEREAS, Recent scientific reports have provided new evidence that increasing concentrations of carbon dioxide in the atmosphere is causing changes in the world's climate patterns, including the potential for severe global warming (the "greenhouse effect"); and

WHEREAS, Emissions of carbon compounds, mainly from the combustion of fossil fuels, are a major contributor to the phenomenon of global warming; and

WHEREAS, Failure to take actions to reverse the trend toward global warming could bring economic, environmental and human disaster previously unimagined; and

WHEREAS, Improvements in energy efficiency offer a low-cost approach to reducing emissions of carbon compounds in the United States without sacrificing health and safety goals; now, therefore, be it

RESOLVED, That the National Association of Regulatory Utility Commissioners (NARUC), assembled in its 100th Annual Convention in San Francisco, California, calls upon the Congress and the President of the United States to swiftly enact legislation designed to improve the efficiency of the nation's use of its energy resources and reduce emissions of the nation's carbon compounds and to assist other nations in doing the same; and be it further

RESOLVED, That such legislation should be based on a least-cost approach, whereby the lowest cost options for reducing emissions of carbon compounds are implemented first; and be it further

RESOLVED, That Congress and the Administration should dramatically increase funding for research and development (R&D) and implementation of energy efficiency and renewable energy resources and henceforth should establish federal energy R&D programs and priorities which reflect the cost-effectiveness of various energy technologies in meeting future energy needs; and be it further

RESOLVED, That such legislation should take into account, and be consistent with, any legislation seeking to address the problem of acid rain, to assure integration of these environmental efforts.

Sponsored by the Committee on Energy Conservation

Adopted November 2, 1988

RESOLUTIONS ADOPTED BY 1988
NARUC ANNUAL CONVENTION IN SAN
FRANCISCO

Resolution on a National Energy Policy
Regarding Global Warming

WHEREAS, There is no scientific agreement as to whether global warming has yet begun and as to what pace such a warming would take; and

WHEREAS, The failure to take actions to reverse the trend toward global warming could bring economic, environmental and human disaster previously unimagined; and

WHEREAS, The public interest demands a coordination of scientific research efforts among governments, universities, research institutes, and nongovernmental organizations to improve the understanding of the world's climate patterns and the phenomenon of global warming and the greenhouse effect; and

WHEREAS, Congress has been considering legislation to coordinate efforts of the Federal agencies and other nongovernment bodies in establishing such a national policy developing and implementing energy research priorities; now, therefore, be it

RESOLVED, That the Executive Committee of the National Association of Regulatory Utility Commissioners, assembled at its 1989 Winter Meeting in Washington, D.C., urges that legislative proposals considered by Congress give adequate consideration to the need to include the interests and expertise of the States in ensuring a fully coordinated, national policy establishing energy research priorities; and be it further

RESOLVED, That the Executive Committee of the NARUC supports a national policy on global warming that is consistent with efforts to develop alternative energy sources and more efficient use of energy through conservation; and be it further

RESOLVED, That the Executive Committee of the NARUC respectfully requests the cooperation of the Federal agencies in seeking the passage of such legislation.

Sponsored by the Committee on Electricity
Adopted March 1, 1989

NARUC
Convention Resolution No. 6
Adoption of State Energy Goals

WHEREAS, There are national energy imperatives which are appropriately addressed at the State level; and

WHEREAS, State energy policies should be approached with renewed vigor in their development and implementation; and

WHEREAS, The Nation continues to be dependent upon petroleum and other non-renewable resources as energy sources; and

WHEREAS, Existing state, national and international energy policies and conditions do not preclude the recurrence of serious problems arising from this dependence; and

WHEREAS, The increase in energy prices has a major adverse impact on the nation's citizens and its economy; and

WHEREAS, Conventional sources of energy are subject to constraints involving supply, transportation, cost, environmental, health and safety considerations; and

WHEREAS, The Nation must identify state imperatives by which to address these problems including, but not limited to strategies to assure adequate, efficient, reliable energy supply and to avoid unnecessary and wasteful consumption; and

WHEREAS, Cost effective energy conservation measures can address such issues appropriately; now, therefore, be it

RESOLVED, That the National Association of Regulatory Utility Commissioners, assembled in its Ninety-sixth Annual Convention in Los Angeles, California, adopts the following goals and urges the states to:

I. Require development of least cost system plans for major gas and electric utilities for meeting energy needs over the coming decades, which plans shall include the following: (1) conservation, (2) renewable resources, (3) use of waste heat or high fuel conversion efficiency and (4) all other resources;

II. Assure increased cooperation and coordination among regions and states by maintaining and broadening the information base on energy use and related subjects, by encouraging energy planning, and by exploring ways to increase the use of power pooling and energy exchange;

III. Continue and develop additional incentives to encourage renewable resource used by adopting ratemaking treatments for conservation programs consistent with the existing treatment of conventional fuel procurement and power supply arrangements;

IV. Adopt legislation providing state regulatory commissions with the authority to compel participation in cost effective conservation programs by all utility companies;

V. Provide additional assistance for disadvantaged energy customers by developing means to improve low income and elderly participation levels in utility conservation programs, by providing additional outreach, training and referral services by developing programs to achieve implementation of audit recommendations; and

VI. Require increased thermal efficiency in buildings and new appliances.

Sponsored by the Ad Hoc Committee on Energy Conservation

NARUC Convention Resolution No. 7

**Resolution Supporting Adoption
by State and Federal Regulatory
Commissions of a Policy Mandating
Electric and Gas Utilities to
Develop and Submit for Approval**

Least-Cost Resource Plans

WHEREAS, It is imperative that the Nation exert more control over its energy future and acknowledge its inherent uncertainties; and

WHEREAS, It is necessary that demand and supply planning be fully integrated to ensure that resources are used prudently and that our energy needs are met at the least possible cost; and

WHEREAS, Energy conserved is a resource and should be subjected to the same need and cost-effectiveness standards as other resources; and

WHEREAS, Conservation can reduce growth in energy demand and thus reduce the need for the construction of new electric facilities; and

WHEREAS, Conservation should be viewed by utilities as an alternative to new supply options; and

WHEREAS, Implementation of this policy will provide the ability to select resources based on the most important factors: need, cost reliability and environmental considerations; now, therefore, be it

RESOLVED, By the National Association of Regulatory Utility Commissioners, assembled in its Ninety-sixth Annual Convention in Los Angeles, California, that State and Federal regulatory commissions should adopt a policy which bases the determination

of need for new facilities on the development of a least cost supply plan which evaluates and incorporates all cost effective conservation, load management and alternate energy sources in the least cost supply plan; and be it further

RESOLVED, That least cost resource plans should include consideration of the following: (1) conservation; (2) renewable resources; (3) generating resources using waste heat or generating resources of high fuel conservation efficiency; and (4) all other resources.

Sponsored by the Ad Hoc Committee on Energy Conservation

Adopted November 1984

ATTACHMENT 6

Convention Floor Resolution No. 3

**Resolution in Support of Federal Research
on Energy Conservation**

WHEREAS, An energy policy that provides a balanced reliance on supplies and demand is essential to the Nation's future well being and security; and

WHEREAS, The current worldwide oil surplus and resulting lower oil prices are providing a misleading signal that the energy crisis has passed; and

WHEREAS, The ability of the Nation to adjust to future energy supply constraints will depend on the development of new energy efficient products and technologies; and

WHEREAS, The gestation period between the initiation of research and the introduction of new products and technologies into the marketplace is as long as 20 years; and

WHEREAS, A vigorous conservation research program must be given a high priority now if the Nation is to have the new technologies and products needed when energy supplies become increasingly constrained; and

WHEREAS, Increased energy efficiency is cost effective and will help achieve environmental goals including a reduction in acid rain, the "greenhouse effect" and oxidation damage to trees and crops; and

WHEREAS, The building industry, unlike the transportation and industrial industries, is not dominated by large firms which have the motivation and resources to invest in reducing their energy expenditures; and

WHEREAS, Building energy efficiency is of particular interest to public service commissioners; now, therefore, be it

RESOLVED, That the National Association of Regulatory Utility Commissioners (NARUC), assembled in its Ninety-eighth Annual Convention in Phoenix, Arizona, requests Congress and the Department of Energy to increase the funding for conservation research, particularly for the building sector, so that a balance will be achieved in our Nation's energy programs.

Sponsored by the Committee on Energy Conservation
Adopted November 19, 1986

JOINT CENTER FOR HOUSING
STUDIES OF THE MASSACHUSETTS INSTITUTE OF
TECHNOLOGY AND HARVARD UNIVERSITY

SUMMARY

The following is an excerpt from a 1986 study of "The Effect of the Shelter Industry Energy Rated Homes™ System on Homeownership" by The Joint Center For Housing Studies of the Massachusetts Institute of Technology and Harvard University of the effect of a uniform rating system implemented across the country. This study was conducted after an initial pilot program in Washington. The program is working. State governments and the housing industry have now incorporated to expand this uniform home energy system to Alaska, Arkansas, Vermont, and Mississippi.

Recent changes in housing market conditions have led to increased affordability concerns for many prospective homebuyers. In response to these changes a Pacific Northwest program, designed to make homeownership more affordable by providing more favorable mortgage finance terms to purchasers of energy-efficient housing, has been conceived and entered a pilot stage. The purpose of this report is to describe this program, analyze the affordability issues that motivate it, and provide estimates of its likely effect on homeownership for five U.S. metropolitan areas.

The Shelter Industry ENERGY RATED HOMES™ System is a voluntary effort that recognizes the economic benefits of energy efficiency to homebuyers, lenders, realtors, builders, and secondary market investors. Houses in western Washington are rated for energy efficiency using a uniform rating system developed under this program. Given the lower costs of maintaining energy-efficient houses, participating lenders are permitted by secondary market institutions to offer higher debt-to-income ratios to purchasers of such homes. Both the Federal Home Loan Mortgage Corporation and the Federal National Mortgage Association have endorsed Energy Related Homes and agreed to purchase loans with higher ratios of housing-related costs to income from participating primary lenders. The Energy Rated Homes Program received initial funding from the Bonneville Power Administration and the Washington State Energy Office. It has also been endorsed by the Board of Directors of the Federal Home Loan Bank of Seattle. About twenty Pacific Northwest lenders have been participating in a pilot stage of the Program, and over 2,000 homes have been rated for energy efficiency.

"The analysis of affordability presented in this report points to three conclusions that are highly relevant to the likely effect of the Energy Rated Homes Program (a uniform home energy rating system). (1) Inflation has distorted the costs and benefits of owning a home. Whereas inflation-induced appreciation in house values is expected to accrue over the ownership period, high mortgage interest rates must be faced immediately by a buyer. This creates liquidity constraints that have been known as affordability problems. (2) These aberrations in homeownership costs have caused real changes in households' housing decisions. Higher-income households are purchasing at higher than expected rates, whereas the opposite is true for lower-income households. Any effort that assists these households to achieve homeownership by easing these liquidity constraints will be serving a useful public purpose. (3) The situation for trade-up buyers is very different than for first-time buyers. Trade-up buyers—many of whom have profited by high rates of appreciation in house prices—can use their built-up equity to compensate for the large cash requirements of home buying. First-time buyers do not have this option.

The Energy Rated Homes Program may be expected to have either of two effects on the demand for owner-occupied housing. By permitting an increase in the percentage of income that the household can spend on housing costs for an energy-efficient home, it effectively lowers the household income required to qualify for a mortgage on a given home. This lower income requirement should have the effect of permitting some non-owners to enter the homeownership market for the first time. The Program may also have the effect of increasing the value of housing that may be purchased by households with a given income. Thus both first-time buyers and trade-up buyers may demand houses of higher value under the Program. Three potential sources of increased demand for owner-occupied housing are thus estimated: (1) housing demanded by first-time buyers who would not have otherwise purchased a home; (2) additional housing demanded by first-time buyers who would have purchased a home in the absence of the Program, and (3) additional housing demand by trade-up buyers who would have "traded up" in the absence of the Program.

The estimates presented here indicate the possibility of substantial increases in the demand for owner-occupied housing as a result of a program of this type. Although the largest effect in terms of housing value is found for "trade-up" buyers (who typically account for 60 to 65% of the homes purchased), the potential clearly also exists for a substantial number of new households to be brought into the homeownership market. *Estimates of the maximum percentage increase in the number of new first-time homebuyers range from 11 to 22%. This means that if implemented nationally, an Energy Rated Homes Program could induce an extra one-quarter million households to become first-time homebuyers.* Although the actual effect in any given year would be less due to considerations other than monthly housing costs, the results nevertheless point to the possibility of a very important effect in light of the importance to households of lender-imposed restrictions on monthly housing costs.

The question of the degree to which the housing stock can accommodate the increases in demand for energy-efficient homes is also addressed. It is not impossible to envision a situation where energy efficiency is so greatly valued by homebuyers, that large numbers of sellers will respond by making energy-related improvements. However, given the significant portion of the housing stock that is not energy-efficient, and given the sluggishness evident in making major energy improvements, recent history suggests that a mechanism will be required to make an adequate number of energy-efficient homes available to potential new homeowners over the longer run. Since it seems unlikely that large numbers of sellers would make substantial energy investments in order to market their homes, a mechanism that permits buyers to modify houses as part of the purchase transaction appears necessary.

Home Financiers Need Their Own Energy Rating System

by Gerald J. Levy

At a time when many issues divide the housing finance industry, there is at least one subject—energy—that is bringing national leaders of savings institutions, secondary mortgage market firms, private mortgage insurance agencies, mortgage bankers, real estate salespeople, and builders together into a common effort.

The effort, called Energy Rated Homes™, is aimed at the adoption of a uniform energy evaluation and rating system for use in real estate sales and mortgage lending. Not only the nation at large, but also the housing finance and related industries and companies, will benefit from the system through increased sales and loan volume.

The national steering committee is co-chaired by Kenneth J. Thygeson, chief executive officer, Imperial Corporation of America, San Diego, California, and John Teusch Jr., chairman and chief executive officer, Rainier Financial Services, Seattle, Washington. The committee also includes the current or past presidents or chairmen of major industry trade associations, secondary mortgage market organizations, two federal home loan banks, and many other leading primary lenders, builders, and realty executives.

Background and Support

Why are so many of those in the business of housing America concerned with energy conservation at a time when energy prices have fallen, interest rates are down, and the national spotlight seems to be focused elsewhere? The answer is simple: just as interest rates are bound to rise sooner or later, so too are energy prices. And when that happens, the housing finance and related industries need to be in a much better position than they are

in today to gauge the effects—both positive and negative—that rising energy costs will have on home ownership.

Those of us who remember the oil prices of the late 1970s and early 1980s perceive a clear need for a trusted, uniform standard by which to evaluate a home's energy efficiency. The number of government-run, utility-sponsored, and private energy programs in the country is mind-boggling. Most of us in housing finance have opted to stay out of the issue entirely rather than deal with the myriad rules and regulations associated with different programs. The result is a tremendous number of energy-related programs created and aimed at the home mortgage and real estate sales industries, and very few, if any, programs generated within the housing finance industry as a whole.

The Energy Rated Homes coalition of secondary and primary lenders, mortgage insurers, real estate professionals, and builders set out to design a workable method of incorporating energy efficiency that would be industry controlled and tailored to meet our needs for a non-biased, nonregulatory, standard system. Beginning in 1981, through the efforts of the Society of Real Estate Appraisers' chapter in Seattle, Washington, and secondary market representatives of federal and other agencies, a system was developed that would incorporate an energy factor into every aspect of real estate sales and mortgage lending.

Four components make up the system: a technical energy-rating form for use

(with regional climate and utility cost adjustments) as an addendum to the standard appraisal required by the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac); training materials for underwriters, loan officers, appraisers, and real estate agents; marketing materials, including television and radio spots, for use by participating real estate companies, builders, and lenders; and public information materials for use in marketing or sales.

The system, now in the initial stages of operation at test sites in Vermont, Arkansas, and Alaska, is administered jointly by the 30-member steering committee and the Western Resources Institute, a non-profit spinoff from the University of Washington (Seattle). As the project moves forward, a national foundation will be formed to take over long-term administration and operation.

Using Energy to Make Loans

The Energy Rated Homes system allows the thrift industry, for the first time, to use energy considerations comprehensively and consistently in underwriting and marketing loans. How? Participating lenders—along with participating realty companies, builders, and multiple listing services—offer home buyers an energy evaluation and improvements analysis as part of the loan package. (The home buyer pays a fee for the service.)

The energy evaluation looks at a number of features: the insulation of the ceilings, floors, walls, and windows; caulking and weatherstripping; solar energy use or potential use; and the hot-water, heating, and cooling systems. Each of these is rated for efficiency on a 1-to-100-point scale; then the house is given an overall

Gerald J. Levy, past chairman of the United States League of Savings Institutions, is chairman of Guaranty Savings & Loan Association, Milwaukee, Wisconsin.

energy efficiency rating on a 1-to-5-star scale, with 5 stars meaning high efficiency.

The analysis also supplies an estimate of the annual energy cost of a house. The difference between that cost and comparable average energy costs for the area translates the house's energy efficiency into dollars saved per month. That figure can be used to justify expanded debt-to-income and debt-to-payment ratios for energy-efficient homes, under the rationale that purchasers of energy-efficient properties will have increased residual income from their energy cost savings that can be applied to the loan. For example, to qualify for a fixed-rate, 30-year \$108,000 mortgage at 12 percent, with a loan-to-value ratio of 90 percent, a would-be buyer of a house with a two-star rating would have to have a monthly gross income of \$4,949. If the house's rating were five stars, that would-be buyer would qualify for the loan with a monthly gross income of \$4,650.

The improvements analysis can be used to justify energy improvement loans—either incorporated with the mortgage or as a seller buydown—that can make the home buyer eligible for the expanded qualifying ratios. Energy Rated Homes program operators—usually nonprofit entities set up for the purpose—provide reinspection services to participating lenders to certify that the improvements have been completed and that the dwelling does indeed meet the energy-rating level needed to justify the higher debt-to-income ratio.

Benefits to the Industry

Lenders can use the plan to help draw energy-conscious home buyers to them, to help qualify trade-up and refinancing customers for larger loans, to help low-income, first-time buyers qualify for homes they normally would not qualify for, and to attract customers for home improvement loans that can be used to improve the energy efficiency of the borrower's home. And lenders need not fear having to keep such loans in portfolio. Although secondary market ratios have tightened somewhat for standard mortgages, both Fannie Mae and Freddie Mac have energy loan policies that allow lenders to use the Energy Rated Homes sys-

tem. (Fannie Mae's policy allows a 2 percent increase in the debt-to-income ratio, while Freddie Mac's policy allows up to a 4 percent increase.) Secondary market lenders also allow the escrowing of energy loan funds so that energy improvements can be made up to 120 days after closing.

The creation of a standard energy-rating system means that rationality has entered debate on the issue. The value of conservation measures can be clear to all. The potential sales benefits from rationalizing the system, for example, are quite impressive. A recent analysis, commissioned by the Federal Home Loan Bank of Seattle and undertaken by the Joint Center for Housing Studies at Harvard and the Massachusetts Institute of Technology, found a potential increase in qualifying first-time buyers ranging from 11 percent to 21 percent in five U.S. cities (Chicago, Illinois; Hartford, Connecticut; Houston, Texas; Portland, Oregon; and Seattle, Washington). And the reach of the program is broad: the report notes significant possible benefits not only for first-time buyers, but also for trade-up buyers and low-income renters who are potential buyers.

Operating the System

The pilot programs in Vermont, Alaska, and Arkansas are a significant step toward national implementation. They also suggest a pattern for other states.

In the three test cases, the initiative came from either state housing finance agencies or state energy agencies, which have provided seed money. Oversight and implementation support for the program comes from voluntary Energy Rated Homes steering committees in each state.

The Energy Rated Homes of Alaska steering committee, for example, is made up of leaders representing the thrift, mortgage banking, building, real estate sales, and appraisal industries. The committee also includes the director of the Alaska Housing Finance Agency and representatives of public utilities. The steering committee's role is to help Energy Rated Homes local and national staff educate the housing industry about the project, assist in the selection of program operators (in Vermont, for example, the Vermont Housing Finance Agency is con-

sidering operating the program as a general service to the housing industry); help the operator to recruit lenders, realty companies, builders, and multiple listing services; and provide oversight to ensure the success of the effort.

The Energy Rated Homes operator markets the system to the housing industry; assists the industry with consumer marketing efforts; and ensures quality control of ratings provided to consumers either through the lender, the lender's appraiser, or the operator's own ratings and improvement worksheets. The operator works with local multiple listing services and monitors the classified sections of local newspapers to integrate information about the energy-rating system into these important consumer information vehicles.

What Thrifts Can Do

Thrifts can be tremendously helpful in the effort to standardize the approach to energy in the mortgage loan process. First, as the system expands into new areas, thrift organizations can endorse the effort at the national level and encourage state savings leagues to become involved in establishing it. State leagues may wish to initiate the program themselves by contacting their respective state housing finance agencies, energy agencies, or the program's national staff in Seattle. Second, thrifts can join the Energy Rated Homes system when it is introduced in their market areas and begin using the system to qualify more buyers.

The Energy Rated Homes system is a winner for all involved. The thrift industry wins because it can qualify more families for home ownership. Realty professionals and builders win because they can use the system to their advantage in selling both older homes that have been renovated for energy efficiency and newer homes, which are, generally speaking, more energy efficient than existing housing. Buyers win because the system means that they can qualify for homes that will cost less to heat in the winter and cool in the summer. And everybody wins because an alliance of housing development and housing finance enterprises is working cooperatively to make better housing more affordable for more Americans. □

Convention Floor Resolution No. 8

Resolution on Appliance Standards

WHEREAS, A National Appliance Energy Conservation Act will provide very significant energy savings through substantially improved appliance efficiency; and

WHEREAS, Such an Act will reduce the complexity of nationwide marketing of appliances by applying consistent efficiency standards on a nationwide basis; and

WHEREAS, Continued investment in energy conservation is an essential component of national energy independence and economic growth; and

WHEREAS, Energy conservation will permit the United States to become more independent of the world oil market and will reduce our vulnerability to the interruption of foreign energy supplies; and

WHEREAS, Appliance energy conservation standards are one of the most cost effective means of achieving energy efficiency; and

WHEREAS, Agreement on national appliance standards has been reached between manufacturer and consumer interest groups; and

WHEREAS, National appliance energy standards more stringent than existing State standards should be set by Congress; and

WHEREAS, National appliance energy standards will benefit both appliance manufacturers and consumers by avoiding the costs of complying with multiple State appliance standards; now, therefore, be it

RESOLVED, That the National Association of Regulatory Utility Commissioners (NARUC), assembled in its Ninety-eighth Annual Convention in Phoenix, Arizona, supports the concept of a National Appliance Energy Conservation Act which sets standards that are effective and reasonable, while at the same time NARUC supports State initiatives to establish appliance standards, until such time as Federal legislation is effective; and be it further

RESOLVED, That the NARUC, in endorsing and strongly supporting this Act, specifically requests that the preemption process should be sufficiently flexible to allow States to address more stringent standards based on State specific economic and technical issues as they may arise.

Sponsored by the Committee on Energy Conservation
Adopted November 19, 1986

STATEMENT OF POSITION OF THE
NARUC ENERGY CONSERVATION COMMITTEE
ON LEAST-COST-PLANNING PROFITABILITY

A utility's least-cost plan for customers should be its most profitable plan. However, due to the fact that incremental energy sales increase profits, traditional rate-of-return calculations generally provide substantially lower earnings to utilities for demand-side resources than for supply-side resources. For that reason, profit motive generally encourages utilities to invest in supply-side resources even when demand-side alternatives are clearly identified in its resource plan as being the least-cost resource.

The loss of profits to utilities from relying more upon demand-side resources is a serious impediment to the implementation of least-cost planning. This obstacle to least-cost planning should be addressed. There are identified mechanisms for offsetting the profit-erosion problem.

Therefore, it is the position of the Energy Conservation Committee that State commissions:

- (1) should require their utilities to engage in least-cost planning;
- (2) should consider the loss of earnings potential connected with the use of demand-side resources; and
- (3) should adopt appropriate mechanisms to compensate a utility for earnings lost through the successful implementation of demand-side programs which are a part of a least-cost plan and seek to make the least-cost plan a utility's most profitable resource plan.

(Adopted unanimously by the Committee on Energy Conservation on July 26, 1988.)

PURPA CAPACITY FILED WITH THE FEDERAL ENERGY REGULATORY COMMISSION

Fiscal Year 1980 through first quarter fiscal 1988

(megawatts)

	1980	1981	1982	1983	1984	1985	1986	1987	1988*	Total
Cogeneration	282	781	3,136	3,522	3,633	7,613	11,581	12,068	1,653	44,269
Biomass**	162	382	860	996	1,241	1,664	2,100	1,393	353	9,151
Hydro	108	39	62	397	372	305	1,774	152	81	3,290
Wind	76	24	127	325	270	603	298	220	2	1,945
Fossil Waste	0	13	29	235	110	346	948	1,198	296	3,175
Geothermal	76	80	60	119	168	164	1,327	140	23	2,157
Solar	0	0	0	92	94	42	62	30	60	380
Other***	0	0	0	0	0	0	26	1	4	31
Total	704	1,319	4,274	5,686	5,888	10,737	18,116	15,202	2,472	64,398

* Represents first quarter of fiscal year: Oct. 1, 1987 - Dec. 31, 1987

** Includes wood, agricultural wastes and biomass-fired cogeneration

*** "Other" small power sources are not defined by FERC but are generally small, fossil-fueled facilities that apply for self-certification.

Conservation Committee
Resolution on FERC's PURPA Initiatives

WHEREAS, FERC has commenced a national debate on possible reforms to PURPA; and

WHEREAS, Many states have already successfully implemented bidding procedures for utility purchases from qualifying facilities; and

WHEREAS, Uncertainty about the legality of bidding systems may be preventing other states from pursuing bidding procedures; and

WHEREAS, At least one state has successfully extended competitive bidding to conservation and other demand side measures; and

WHEREAS, FERC has proposed expanding bidding to IPP's and this expansion raises issues which should be explored in more detail; and

WHEREAS, Intra- and Interstate transmission access is an essential component of the efficient structure of the electric utility industry; now, therefore, be it

RESOLVED BY THE ENERGY CONSERVATION COMMITTEE OF NARUC:

1. That FERC proceed on an expedited basis to issue a policy statement or interpretative ruling making it clear that the use of bidding procedures for purchases from qualifying facilities is inconsistent with PURPA and FERC's implementing regulations.

2. That to assure efficient least cost planning FERC encourage states to include conservation and demand side measures on an equal basis with supply side sources in state bidding systems.

3. That FERC should not preempt the states in their design and implementation of avoided cost calculations and competitive bidding systems.

4. That FERC commence a formal rulemaking proceeding to receive comments on proposals to treat IPP's on a non-cost of service basis.

5. That FERC place its highest priority on a thorough study of transmission access and pricing reforms including but not limited to identifying legislative proposals designed to assure an efficient bulk power market.

6. That FERC explicitly recognizes state regulatory commissions' jurisdiction over intrastate wheeling access and related pricing matters.

Adopted March 2, 1988

Central Maine Power

NEWS

Contact: F. CHIARAVALLOTTI

AUGUSTA, MAINE, February 14, 1989 -- Central Maine Power Company today announced it has entered agreements to purchase energy savings from Northeast Energy Management, Inc. (NEMI) and SESCO, Inc. The energy savings will result from NEMI's and SESCO's efforts to market conservation and energy management services directly to CMP's customers.

Both contracts were negotiated under the terms of CMP's Power Partners Program, which was introduced in December, 1987. The program allows private companies to "sell" CMP energy savings by placing energy management projects on an equal competitive bidding basis with independent power producers.

NEMI will market its energy management services, principally in the areas of lighting and process retrofits, to commercial and industrial customers in CMP's service area. NEMI estimates potential savings from its efforts of 48 million kilowatt-hours (KWH) a year and 9.5 megawatts (MW) of capacity.

During its 20-year contract with CMP, NEMI will install energy efficiency improvement projects during the initial five years. CMP will monitor each project's effectiveness on a semi-annual basis and pay NEMI monthly for kilowatt-hour savings as they occur.

SESCO has signed a five-year Power Partners agreement with CMP to provide weatherization, insulation and other energy management services to 10,000 homes in the Lewiston-Auburn area. The SESCO project could save some 20 to 25 million KWH's annually and reduce demand by about 5 megawatts.

-more-



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dependent upon earning the trust of its investors, employees, customers and their government representatives

Essex Drive, Augusta, Maine 04330 (207) 623-3521

CMP will pay SESCO one half of the net present value of a home's projected lifetime electricity savings as soon as all measures are installed. After the initial payment, CMP will monitor the home's energy usage for one year and then make a final payment based on the home's actual savings projected over time.

The NEMI and SESCO energy management project bids were submitted in response to Requests For Proposals (RFP's) issued by CMP for specific blocks of power and competed against cogenerators and small power producers for avoided cost rates.

"We are excited about these new programs," said Richard A. Crabtree, CMP's Senior Vice President, Customer Services and Division Operations, "because they represent an active, 'door-to-door,' personal approach to providing energy efficiency measures to our customers."

Negotiations on these Power Partners contracts began over six months ago. "These contracts are not in any way the result of the rejection of our proposal to purchase power from Hydro-Quebec," Crabtree said, "nor should they be taken as an indication of a lack of need for such sources of power."

"These programs represent a good investment for CMP and for its customers," Crabtree said. "We believe they will prove to be a valuable part of any energy plan for Maine's future."

The Power Partners program is part of CMP's ongoing efforts to promote conservation and energy management. CMP estimates it will spend more than \$100 million over the next five years on programs that encourage customers to use electricity wisely and efficiently.

Central Maine Power

NEWS

For Release: Immediate

Contact: Clerk Irwin, x 3036

WATERVILLE, Maine, Sept. 23, 1988 -- In a first-of-its kind contract anywhere, Keyes Fibre Co. has agreed to sell electricity released by efficiency improvements to Central Maine Power Company.

The 15-year contract was signed at the Keyes Fibre administrative offices here today. It is the first signing in the "Power Partners" program authorized by the Maine Public Utilities Commission, and will entail total payments over the life of the contract worth about \$2 million in present-value terms.

From other CMP customers' point of view, the 7.33 million KWH savings guaranteed by the contract each year -- enough to supply about 900 typical residential customers -- is the equivalent of having a new generating plant come on-line. But the cost is 5 percent lower and there are no adverse environmental impacts involved.

The contract was signed by Keyes' Vice President and Chief Financial Officer Samuel W. Dickson and by CMP Marketing Vice President Lynn K. Goldfarb.

Keyes will produce the electricity savings by investing in new pulping equipment to use secondary fiber like newsprint and paper-mill waste in its formed-fiber products operation. The changes will reduce Keyes' electric bill while maintaining current production levels.

CMP operates 18 energy management programs that have already released more than 100 million KWH for customers' use and trimmed last winter's peak demand by more than 100 megawatts of power. The utility recently announced a five-year program of more than \$100 million to maintain and expand energy-management programs for its customers.

(30)



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ATTACHMENT 14

Convention Floor Resolution No. 4

Resolution on State and Local Energy Assistance Programs

WHEREAS, The intent of oil overcharge refunds is to redress past pricing grievances, and not to balance the Federal budget; and

WHEREAS, The uses to which these monies can be put were defined so as to insure that all aggrieved consumers receive meaningful restitution; and

WHEREAS, For a decade, Congress has appropriated funds to implement conservation efforts that provide long-term solutions to national energy problems and to assist individual energy consumers in permanently reducing their on-going energy bills; and

WHEREAS, Appropriated amounts over the past decade have assisted only a small fraction of the national weatherization need; and

WHEREAS, Oil overcharge refunds offer a one-time opportunity to make significant advances toward long-term reduction of energy bills through housing weatherization and other long-term conservation efforts; and

WHEREAS, Reduction of the level of funding would only serve the short-term expedient of attempting to balance the budget at the expense of energy conservation programs and the citizens whom oil overcharge refunds are intended to benefit; now, therefore, be it

RESOLVED, That the National Association of Regulatory Utility Commissioners (NARUC), assembled in its Ninety-eighth Annual Convention in Phoenix, Arizona, urgently requests Congress to appropriate funding at a FY 1986 level or more for the U.S. Department of Energy's State and Local Energy Assistance Programs including the Low-Income Weatherization Program, the State Energy Conservation Program, the Energy Extension Service, and the Institutional Conservation Program.

Sponsored by the Committee on Energy Conservation
Adopted November 19, 1986

NARUC RESOLUTION

Resolution Supporting the Development and Use of Compressed Natural Gas Vehicles

WHEREAS, The Clean Air Act requires States and municipalities to develop State Implementation Plans to comply with the anti-pollution requirements of the Act; and

WHEREAS, Seventy to eighty metropolitan areas in the U.S., with approximately half the nation's population, have been identified by the U.S. Environmental Protection Agency (EPA) as being "non-attainment" areas for carbon monoxide, nitrous oxides, ozone, and sulfur oxides; and

WHEREAS, Strict standards for diesel engine emissions, including particulates and nitrous oxides, will come into force in 1988, 1991 and beyond; and

WHEREAS, The diesel engine industry is now researching and developing new diesel engines to run on non-petroleum fuels; and

WHEREAS, The use of compressed natural gas, compared with petroleum fuels, can significantly reduce emissions of ozone precursors and carbon monoxide; and

WHEREAS, The United States currently imports over forty percent of its petroleum requirements from foreign sources and it is currently estimated that such imports will exceed fifty to sixty percent

through the 1990s, to the detriment of the nation's trade balance and national security; and

WHEREAS, The U.S. transportation sector accounts for sixty three percent of the nation's petroleum consumption; now, therefore, be it

RESOLVED, That the Executive Committee of the National Association of Regulatory Utility Commissioners (NARUC), assembled in its 1988 Summer Meeting in San Diego, California, thinks that the widespread development, promotion and use of compressed natural gas in the transportation sector will have important environmental and national security benefits and will assist in improved utilization of natural gas facilities, all of which are in the long term public interest; and be it further

RESOLVED, That the NARUC believes that Federal and State agencies should take such steps as are necessary to encourage and permit such development, promotion and use of compressed natural gas in the transportation sector.

Sponsored by the Committee on Gas
Adopted July 28, 1988

Resolution on Natural Gas Vehicles

WHEREAS, Air quality is a problem of major concern throughout the nation; and

WHEREAS, The Federal Clean Air Act mandates regions to meet the national ambient air quality standards for ozone and carbon monoxide before December 1987, but 76 metropolitan areas do not meet the ozone standard, and 40 areas do not meet the carbon monoxide standard; and

WHEREAS, Motor vehicle emissions are a major cause of much of the nation's air pollution; and

WHEREAS, Natural gas vehicles (NGVs) are the cleanest hydrocarbon fueled vehicles and most economical of all the vehicles available, and NGVs produce only small amounts of carbon monoxide, reactive hydrocarbons and nitrogen oxides; and

WHEREAS, NGVs also cut down on gases, such as carbon dioxide, that contribute to what has been called the greenhouse effect; and

WHEREAS, Anticipated advancements in technology will make NGVs even cleaner; and

WHEREAS, Natural gas, unlike other alternative fuels, is available in plentiful supply and at a reasonable cost; and

WHEREAS, Natural gas utilities have the expertise and experience to help develop the needed new technology and guide its implementation; now, therefore, be it

RESOLVED, That the Executive Committee of the National Association of Regulatory Utility Commissioners, assembled at its 1989 Winter Meeting in Washington, D.C., declares that legislation is needed to encourage the development and application of natural gas vehicles.

Sponsored by the Committee on Gas
Adopted March 1, 1989

Senator WIRTH. Thank you, Mr. Wiel.
Finally, Mr. McCollam.

**STATEMENT OF WILLIAM McCOLLAM, JR., PRESIDENT, EDISON
ELECTRIC INSTITUTE**

Mr. McCOLLAM. Thank you, Senator Wirth. For the record, my name is William McCollam, Jr. I am President of the Edison Electric Institute which is the association of the Nation's investor-owned electric utilities.

Our industry is pleased to present our views on S. 324 which addresses, as you recognize, many complex issues having profound significance not only for our customers and our Nation, but for all the peoples of our planet. The industry would like to offer its commendation to Congress and this committee for their efforts to gather facts and information on a very complex issue prior to selecting a public policy to ensure the protection of the earth's environment.

Since my time is limited, the contents of the bill are extensive, my oral statement will cover only the highlights of my written testimony which has previously been furnished to the committee, and I would ask that the written testimony be included in the record.

Some scientists speculate that a rise in average global temperature of 4 or 5 degrees Centigrade could mean climate changes with serious societal implications. Admittedly we are not certain what climatic changes might take place. However, we can expect that such changes could, obviously, have significant effects on agriculture, rainfall, hydrology, sea level, storm events, demography and human health. We must recognize, however, that our knowledge is currently so limited we cannot yet judge with any accuracy what might be the results of continued increases in greenhouse gases.

But that is not to suggest that rational public policy cannot be crafted to address the issue. We strongly advocate a holistic approach and similarly support rational energy policies that address the other considerations, not only global environmental issues, but international cooperation in the development of diverse energy sources.

The electric utility industry is aggressively pursuing several paths designed to meet the Nation's energy needs while reducing atmospheric emissions. In fact, we are in the process of preparing a set of policy recommendations to be released shortly. A good many of these recommendations are consistent with various sections of S. 324. In this report the promotion of energy efficiency as a matter of national policy is given first priority.

It is important to stress in the strongest possible terms that this industry and its customers have combined to achieve substantial improvements in efficient production and use of electricity, and that energy efficiency does play a crucial role in industry strategies for an adequate, reliable, affordable and environmentally sound electricity supply for the future.

For example, utility-sponsored programs designed to increase customer end-use efficiency have increased from about 134 programs in 1977 to nearly 1,300 today. They range from informational materials to customer use to direct control of customer loads.

They run the gamut from mass media advertising to on-site energy audits. They include incentives from alternative pricing structures to direct cash rebate payments for the purchase of high efficiency end-use equipment, zero or below-market rate financing of efficiency improvements, shared savings programs, direct marketing of new efficiency technologies, construction and design assistance, irrigation pump testing, relamping programs, and many others. This listing, obviously, is incomplete but is somewhat illustrative of the broad range of activities by which we seek to improve energy efficiency.

The electric utility industry now spends in excess of \$1 billion per year in direct support of these efforts and the amounts continue to increase. The result of these efforts is no less impressive. The capacity savings resulting from these efforts since 1977 are estimated at more than 21,000 megawatts—that is to date—and are projected to exceed about 45,000 megawatts by the year 2000.

If we assume a conservative construction cost of new capacity of about \$1,000 per kilowatt—and you would recognize that is conservative—this means that about \$21 billion of new investment has been avoided so far, and about \$45 billion we estimate will be saved by the turn of the century, the year 2000. By any standard of judgment, this record is indicative of a serious and long-term commitment of our industry to energy efficiency.

Further, electric utilities continue to work closely with state regulatory commissions and customers to find ways to improve those programs. This means development of new, more efficient end-use applications as is done at the Electric Power Research Institute and backed by industry-wide funding. It means continued support for such sensible legislation as the National Appliance Energy Conservation Act of 1987. It means adoption of such model energy codes as was recently promulgated by the Council of American Building Officials for new construction. Finally, it means supporting sound public policy in light of growing public concern over possible global climate change.

Conservation, the efficient use of fossil fuels, the development of renewables, and the use of nuclear power must be considered simultaneously. There is no single answer which satisfactorily addresses the issues of global climate change, energy supply, national security, international competitiveness, economic health, efficiency and productivity. Policies solving one problem at the expense of another should not be tolerated. For example, to mandate flu gas scrubbers to remove sulfur dioxide would, in fact, increase emissions of CO₂.

In 1988, less than 8 percent of the world's CO₂ was emitted by the U.S. electric utility industry. If we assume that this level went to zero immediately, the result would be that the much-discussed doubling of CO₂ in the atmosphere to the 600 part per million level would be slowed by some three to five years. On the scale most frequently discussed, that is, 50 to 100 years, this delay is almost inconsequential, not unimportant, but inconsequential. We, therefore, believe that any plan calling for urgent and extreme action to reduce utilities CO₂ emissions is premature at best.

We advocate increased electrification, conservation and energy efficiency while continuing to improve our scientific knowledge

base on this issue. We are not suggesting inaction. Quite the contrary. There is much in this bill to support. There are provisions which do, however, merit further scrutiny.

For example, the bill envisions the creation of a national least-cost energy plan by the Secretary of Energy and the Administrator of the Environmental Protection Agency in a scant 18 months. Electric resource planners in nearly every state either now use or are actively considering some form of what has become known as least-cost planning. You have heard that already discussed. It is an understatement to say that this complex and difficult work has taken much time and significant resources and yet, even the definition of least-cost is still a matter of much debate, with as many definitions as there are debaters.

We support the development of a national energy plan which would balance supply, demand, financial and environmental concerns, but believe that Title I of the bill could use more refinement and a more reasonable time frame.

The section of the bill calling for a reduction in energy use per unit of GNP should be revisited in our opinion. At the 2 percent rate of reduction, energy use per unit of GNP would have to be down by a total of 32 percent by the year 2005, and at a 4 percent rate, the measurement would have to be down by some 73 percent. One either has to assume that energy use will remain unchanged and the economy will expand beyond reasonable projection, which is hardly sound reasoning in our opinion, or one must assume a near tripling of energy efficiency. Such a goal also ignores the environmental advantages of the increased use of electricity, in particular, in the industrial and transportation sectors. In any case, we feel this provision is simply unrealistic.

For some years, Federal, state and local governments, along with energy suppliers, have struggled with the residential energy rating systems which could be applied fairly to all residential housing units both new and old. Aside from fuel bias, the most thorny problem has been application of the various systems to existing structures. Unfortunately, the costs associated with bringing an older structure up to new specifications, particularly a residence, are generally very high and the market for residences generally consist of those with limited means. The result is a kind of de facto red-lining which has the unintended effect of discrimination.

There obviously is more work to be done in this area, but there is no reason to delay adoption of a new standard for new construction. I mentioned earlier the recently promulgated model energy code of American Building Officials. This standard improves the energy efficiency of new structures. Under Public Law 678, GSA, DOD, HUD and DOE are all scheduling rulemaking proceedings concerning the adoption of this model energy code. We suggest while work proceeds on a system for existing housing, the adoption of this standard for new construction would be of immediate benefit.

Certain sections of the proposed legislation amend the Federal Power Act and the Public Utility Regulatory Policies Act to create least-cost investment standards, qualifying conservation and qualifying conservation entities. Our position here is one of concern that non-participating consumers do not end up paying twice for the

same reductions. Customers installing conservation of load management equipment receive an immediate benefit from reduced power consumption and, obviously, a reduction in electricity bills. As I mentioned earlier, we often encourage such actions by making a payment to customers installing such equipment or offering favorable financing terms.

In system planning, it is customary to treat the load impacts of demand side measures as deductions from a load forecast. This procedure avoids confusing the utility's cost-benefit assessment with treating demand side megawatts as a direct substitute for supply side megawatts. We have strongly advised FERC against treating them as equivalent and would make the same strong recommendation here.

S. 324 may also permit qualifying facilities to compete as qualifying conservation entities. This raises serious conflict of interest concerns which could be detrimental to electric consumers and the general objectives of the bill.

The bill would also require utilities to purchase from qualifying conservation entities. We believe this will be unnecessary given the new PURPA standards created by the bill and its repeal of section 216 of NECPA.

Finally, we urge the Federal Government to promote and support international cooperation and to encourage all nations to take responsibility for safeguarding the earth's environment. Acting alone will not significantly reduce future emissions. Dictating policy to developing countries is most certainly not the answer in our opinion. We can only address the issue effectively as a global community.

For our part, the electric utility industry intends to open direct lines of communication with energy suppliers around the world to facilitate participation in programs to meet growing energy demands while protecting the global environment. As a matter of fact, we are already involved in liaison activities with most of the major utilities in the world in Europe and certainly in Japan.

Thank you, Mr. Chairman, for this opportunity to present our views on this issue. We do wish you success in your committee's deliberations and stand ready to assist you in any way that we can. That is somewhat of a global overview of a very complex subject that I have tried to address in a very few minutes.

[The prepared statement of Mr. McCollam follows:]

TESTIMONY OF WILLIAM MCCOLLAM, JR.

President, Edison Electric Institute

Before The

UNITED STATES SENATE

ENERGY & NATURAL RESOURCES COMMITTEE

Good afternoon ladies and gentlemen. My name is William McCollam, Jr. I am President of the Edison Electric Institute (EEI), the association of the nation's investor-owned electric utilities. Our industry is pleased to be afforded the opportunity of presenting our views on S. 324, the National Energy Policy Act of 1989, which addresses many complex issues which have profound significance not only for our customers and our nation but for all the peoples of our planet. The industry would like to offer its commendation to Congress and this Committee for their efforts to gather facts and information on this most complex issue prior to selecting a public policy designed to ensure the protection of the Earth's environment.

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The greenhouse effect is real. It exists. It is the reason we are able to live on our planet in relative comfort. Its existence is not in question. What is of concern is that certain societal activities may result in a significant change in the current global climate. To link any potential changes in this climate with the hot summer and drought of 1988 is not scientifically supportable. However, the electric utility industry does not intend to ignore the possibility that a warming trend may be occurring.

The Earth's temperature represents a balance between incoming solar energy and outgoing infrared radiation. The Earth's temperature is influenced by several factors, including the retention of some of the heat by atmospheric gases. It is possible that an increase in concentration of atmospheric gases which absorb the outgoing infrared radiation could result in a rise in average global temperature. Such increases in these gases, such as carbon dioxide (CO₂) concentration, are occurring. Similarly, other greenhouse gases are increasing in the troposphere. Over

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the past century, data indicate an increase of about 0.5 degrees Centigrade in mean global temperature but, because of climatological variability, we are not sure if the change is within the range of normal oscillations. Some speculate that a continued increase in concentration of these greenhouse gases, however, could raise the mean global temperature by 2 to 5 degrees Centigrade within the next century or so.

A number of gases in the atmosphere can serve as absorbers of infrared radiation. To date, CO₂ has received the most attention. In addition to CO₂, other greenhouse gases are receiving attention. Among these are nitrous oxide, methane and chlorofluorocarbons (CFCs).

Some scientists speculate that a rise in average global temperature of 4 or 5 degrees Centigrade could mean climate changes with serious societal implications. Admittedly, we are not certain what climatic changes would take place. However, we can expect that if such changes do occur,

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they could have significant effects on agriculture, rainfall, hydrology, sea level, storm events, demography and human health.

Although we can envision a multitude of serious potential consequences to society, we must recognize that our knowledge is currently so limited that we cannot yet judge with any accuracy what might be the results of continued increases in greenhouse gases. We are hampered by two major uncertainties: the global carbon cycle and the modeling of global climate.

Predicting what sort of temperature changes might face the planet over the next century or so depends on several factors, including the knowledge of future atmospheric concentrations of greenhouse gases. Future CO₂ levels depend on factors which, at best, are difficult to quantify, such as land use, atmospheric retention of emitted CO₂, fuel use and

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energy growth. These contributing factors, in turn, are dependent on others, most of which are fraught with a high degree of uncertainty.

Worldwide CO₂ emissions increased from about 1.6 billion tons in 1950 to about 5.1 billion tons in 1980. The North American share of these emissions decreased from about 45% of the total in 1950 to about 25% of the total in 1980. Projections into the future show further decreases in the North American percentage. According to the Electric Power Research Institute, by the year 2000 North American sources will account for only about 15% of total world-wide CO₂ emissions. These projections take into account the rapidly increasing population and energy use in developing countries and increased industrialization in the Soviet Union and Asia.

All of this is not to suggest that rational public policy cannot be crafted to address the issue. We strongly advocate a holistic approach to the issue. Our industry strongly supports rational energy policies that

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address global environmental issues by encouraging international cooperation and by contributing to the development of a diversity of energy sources. The industry is aggressively pursuing several paths which are designed to meet the nation's energy needs while reducing atmospheric emissions. In fact, we are in the process of preparing a set of policy recommendations to be released shortly, and a good many of these recommendations are consistent with the approach taken in various sections of S. 324. While most of this forthcoming report will focus on future capacity needs, the recommendations which will be presented are entirely consistent with the extensive efforts by electric utilities to promote energy efficiency. In this report, the promotion of energy efficiency as a matter of national policy in all sectors of the economy is given first priority. It is important to underscore--in the strongest possible terms--that this industry, its customers and its regulators have combined to achieve substantial improvements in the efficient production and use of electricity, and that energy efficiency plays a crucial role in our industry's strategies

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for an adequate, reliable, affordable and environmentally sound electricity supply for the future.

The history of this industry clearly demonstrates our long-term commitment to energy efficiency. As an example, the number of utility-sponsored programs designed to increase customer end-use efficiency has increased from about 134 in 1977 to nearly 1300 today. These efforts cover all market sectors in a wide variety of ways. They range from the provision of informational materials for customer use to direct control of customer loads. They run the gamut from mass media advertising to on-site energy audits. They include incentives ranging from alternative pricing structures to direct cash rebate payments for the purchase of high efficiency end-use equipment, zero or below-market interest rate financing of efficiency improvements, shared savings programs, direct marketing of new efficiency technologies, construction design assistance and guidelines, irrigation pump testing, re-lamping programs and many others. This listing

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is incomplete but is, nevertheless, illustrative of the broad range of activities by which we aggressively seek to improve energy efficiency. The electric utility industry now spends in excess of \$1 billion per year in support of these efforts, and the amount continues to increase.

The result of these efforts is no less impressive. The capacity savings which are a direct result of these efforts since 1977 are estimated at more than 21,000 megawatts to date and are projected to exceed 45,000 megawatts by the year 2000. If one were to assume a very conservative construction cost for new capacity of \$1,000 per kilowatt, this means that something on the order of \$21 billion of new investment has been avoided so far and as much as \$45 billion will be saved by the year 2000.

By any rational standard of judgment, this record of accomplishment is indicative of a serious and long-term commitment to energy efficiency.

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Further, electric utilities continue to work closely with our state regulatory commissions and our customers to find ways in which energy efficiency and load management programs can be improved. This means development of new and more efficient end-use applications, as is done at the Electric Power Research Institute, backed by industry-wide funding. It means our industry's continued support for such sensible legislation as the National Appliance Energy Conservation Act of 1987 to produce greater gains in efficiency. It means continued support from state commissions to permit utilities the flexibility to conduct pilot programs tailored to local needs which hold the promise of an increased range of services available to customers in all market segments. It means the adoption of such model energy codes as the one recently promulgated by the Council of American Building Officials for new construction. Finally, it means sound public policy in light of growing public concern over possible global climate change.

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Conservation, the efficient use of fossil fuels, the development of renewable energy sources and use of nuclear power all must be considered simultaneously as there is no one single answer which satisfactorily addresses issues of global climate change, energy supply, national security, international competitiveness, economic health, efficiency, productivity and the quality of life. Policies which solve one problem at the expense of another should not be tolerated. For example, to mandate flue gas scrubbers to remove sulfur dioxide (SO_2) would increase emissions of CO_2 .

In 1988, less than 8% of the world's CO_2 was emitted by the U.S. electric utility industry. If we were to assume that this level went to zero immediately, the result would be that the much-discussed doubling of CO_2 in the atmosphere to the 600 parts per million level would be slowed by some 3 to 5 years. On the scale most frequently discussed, 50 to 100 years, this delay is almost inconsequential. Based on the results of an

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admittedly extreme case not contemplated by S. 324, we believe that any plan calling for urgent and extreme action to reduce utility CO₂ emissions is premature at best. We believe it proper to advocate increased electrification, conservation and energy efficiency while continuing to increase our scientific knowledge base on the issue. For example, we support legislation such as S. 251, which calls for scientific assessment of global environment and climate change. In addition, EEI has just undertaken a macro review of the impacts of increased electrification for the industrial and transportation sectors.

As you can see, we are not suggesting inaction. Quite the contrary. There is much in this bill worthy of support and implementation. However, there are some provisions of the bill which merit further scrutiny. For example, in order to attempt a 20% reduction in CO₂ emissions, the bill envisions the creation of a National Least-Cost Energy Plan by the Secretary of Energy and the Administrator of the Environmental Protection

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Agency in a scant 18 months. The content of the Plan as described in the proposed legislation is exhaustive, to put it mildly. According to a recently published study by the Electric Power Research Institute, electric resource planners in nearly every state either now use or are actively considering some form of what has become known as Least-Cost Planning. At least 43 states have functioning strategies in this area or are considering, developing or implementing a process designed to attempt to find the most cost-effective mix of new generating facilities and demand side management. It is an understatement to say that this complex and difficult work has taken much time and significant resources, and yet the definition of the term "least-cost" is still a matter of much debate and discussion with at least as many definitions as there are debaters. The proposed legislation is silent on this matter. We would support the development of a national energy plan which suggests an appropriate balancing of supply, demand, financial and environmental concerns but believe Title I of the bill could use much more refinement and a more reasonable time frame.

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The section of the bill calling for a reduction in energy use per unit of GNP of 2 to 4% PER YEAR through 2005 should be revisited. On the surface, this does not sound like such a terribly large reduction. Upon closer examination, however, it turns out to be a staggering amount of energy. Assuming all goes according to the timetables laid out in the bill, the reductions would have to begin in 1991. At the 2% rate of reduction, energy use per unit of GNP would have to be down by a total of 32% by 2005 and at the 4% rate, energy use per unit of GNP would have to be down by some 73%. By comparison, from 1973 to 1988 energy use per unit of GNP declined by 27%. One either has to assume energy use will remain unchanged and the economy will expand beyond reasonable projections, which is hardly sound reasoning, or one must assume a near tripling of energy efficiency by this measure, which suffers the same deficiency. In any case, this provision is simply unrealistic.

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For some years now, federal state and local governments along with energy suppliers of all types have struggled with the concept of some sort of residential energy rating system which could be applied fairly to all residential housing units, both new and old. The effort has been notable in its lack of success. Aside from fuel bias, perhaps the most thorny problem has been the application of the various systems to existing structures. Unfortunately, the costs associated with bringing an older residence up to new specifications are generally very high, and the market for such residences generally consists of those with limited means. The result is a kind of de facto "red-lining" which has the unintended effect of discrimination. Clearly more work must be done in this area, but there is no reason to delay adoption of a standard for new construction. I earlier referenced our support for the recently promulgated Model Energy Code of the Council of American Building Officials. This consensus standard improves the energy efficiency of new structures when compared with the existing base. Under the provisions of Public Law 678, GSA, DOD, HUD

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and DOE are all scheduling rulemaking proceedings concerning the adoption of this Model Energy Code. Thus, a firm standard now exists for new construction, and the process of adoption has begun. We would suggest that while work proceeds on a system for existing housing, adoption of this standard for new construction would be of immediate benefit.

Certain sections of the proposed legislation would amend the Federal Power Act and the Public Utility Regulatory Policies Act so as to create least-cost investment standards, qualifying conservation and qualifying conservation entities. Our industry's position here is one of concern that consumers do not end up paying twice for conservation and demand reductions. Customers installing conservation or load management equipment receive an immediate benefit from reduced power consumption and a corresponding reduction in the cost of electricity. In addition, as I mentioned earlier, utilities often encourage such actions by making a one-

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time payment to customers installing such equipment or offering very favorable financing terms. It would be inappropriate to consider demand side measures a second time as part of an all source competitive bidding. Consideration of the level and type of demand side subsidies to customers necessarily involves a cost-benefit analysis and assessment of the impact on participating and non-participating customers. Utilities make these assessments, often under state commission guidelines. In system planning, it is customary to treat the load impacts of demand side measures as deductions from a load forecast made without assuming new demand side measures. This procedure avoids confusing the utility's cost-benefit assessment with treating demand side megawatts as a direct substitute for supply side megawatts. We have strongly advised FERC against treating them as equivalent, and make the same recommendation here.

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We are also concerned that S. 324 may permit qualifying facilities to compete as qualifying conservation entities. This raises serious conflict of interest concerns which could be detrimental to electric consumers and the general objectives of the bill. In addition, the bill would require utilities to purchase from qualifying conservation entities. We believe this will be unnecessary given the new PURPA standards created by the bill and its repeal of Section 216 of NECPA. It could lead to wasteful duplication of effort and increased cost to the customer. The provision should be amended to provide merely that state commissions may, to the extent they find it necessary to achieve the bill's conservation goals, require such purchases.

Finally, we would urge the federal government to promote and support international cooperation and to encourage all nations to take responsibility for safeguarding the Earth's environment. Acting alone will not significantly reduce future emissions. Dictating policy to developing

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countries is most certainly not the answer. Only by working together can we address this issue. Since any effects which might occur will be global, activity on the issue should be global as well. For our part, through EEI, the electric utility industry intends to open direct lines of communication with energy suppliers around the world to facilitate participation in programs designed to meet the growing energy demands while protecting the global environment.

Thank you, Mr. Chairman, for this opportunity to present our views on this issue. We wish you success in your committee's deliberations and stand ready to assist in any way we can.

Senator WIRTH. Mr. McCollam, thank you very much. Let me start with you, if I might, and come back up the row there.

I was just listening to the concerns of EEI with the legislation. And as with many others, we would really like to get you on board helping to push this.

I listed six problems, the national least-cost energy plan being done in 18 months. Maybe that is an unrealistic time frame. That doesn't seem to be an enormous problem. Right? The 18-month period of time doesn't seem to be an insurmountable issue.

The 2 percent conservation requirement is only a study, as you know, in Title III. There is no requirement in there which I think your testimony might have suggested that was a requirement. But that is a study, and it wouldn't seem that presents an insurmountable problem.

Energy efficiency codes for old houses. You are suggesting what we ought to do is right away adopt the code for new housing. And then what do we do about the old housing operation?

Mr. McCOLLAM. I think we need to continue working on that and, as a matter of fact, already with the variety of programs under way in most of the states, are working on that problem. But I think that is a much more difficult problem when you consider the type of construction in old homes.

Senator WIRTH. I understand.

Mr. McCOLLAM. I am not suggesting we don't continue to work on that problem. I am suggesting the solution on new houses is a lot easier.

Senator WIRTH. Let's do that right away.

Mr. McCOLLAM. Do that right away, and let's continue to work on the older houses.

With regard to the 2 percent or 4 percent reduction in GNP, we recognize that those are goals.

Senator WIRTH. That is just a study. We are only saying what would happen. Is this feasible?

Mr. McCOLLAM. I would suggest to you, as I said in my testimony, that it is unrealistic, and when you look into it, I believe you will find that to be the case. Unfortunately, there is a tendency for goals of this kind, if you will, to get built into the thinking of people and into legislation, and I think that you just need to be careful about adopting that as a finite goal.

Senator WIRTH. The double payment problem which Mr. Wiel mentioned too in his testimony. Both of you are critical of the provision that is in the legislation on that front. Isn't that right?

Mr. WIEL. Right, for opposite reasons I suspect. But I think the safest thing to do is to simply not address it in legislation and leave the debate in the forum it is in, which is essentially in front of FERC.

Senator WIRTH. Do you agree with that, Mr. McCollam?

Mr. McCOLLAM. I'm sorry. I was listening to my colleague here.

Senator WIRTH. Mr. Wiel suggested leave it in front of FERC. Don't put it in the legislation. Leave it in the forum where it is.

Mr. McCOLLAM. I think that is generally a good idea, and I think there is a tendency on the part of legislation to try to be too prescriptive. I think you need to have more flexibility.

There is another point that I want to emphasize about least-cost planning. Of necessity, I abbreviated a lot of the things in my complete testimony, which you have for the record.

But the proposed legislation on least-cost planning is really silent on definition. And I want to emphasize that emphatically that you need to have a better definition of what is least-cost planning. You have all sorts of programs under way now throughout the United States, and there is a lot of disagreement about what it means. I think it needs to be more clearly and articulately defined.

Senator WIRTH. The final item—and I will leave the next to last—was the need for international cooperation, with which we all agree. And I hope that we have emphasized that as thoroughly as we want to in the legislation. We agree with you completely. We can't do it alone.

Mr. McCOLLAM. I think that is a very important point, and I recognize that you do address that in the bill.

But I can give you a classic example that you have recently read about. In fact, it was the subject of a recent editorial in the Christian Science Monitor earlier this month where the Chinese have objected strenuously to the imposition of the chlorofluorocarbon standards on them because they have a lot of catching up to do with the rest of the world. And if you have the Chinese unwilling to accept those standards, then you have a problem globally. I think you have got to promote global cooperation on all of these things, and I think you recognize that already.

Senator WIRTH. Oh, sure.

Then the final item, one unit of conservation does not equal one unit of production. That was your fifth—

Mr. McCOLLAM. I don't believe I said that.

Senator WIRTH. Maybe I misunderstood.

Mr. McCOLLAM. My statement was when you are looking at the reduction in demand, basically electric demand, a more realistic way to look at it is to reduce your load forecasts by that amount rather than treating that as a resource on the supply side.

And there are some rather sophisticated differences there. And rather than get into it—it's a very difficult thing to explain—I would like to submit some information for the record on this.

Senator WIRTH. I just did not understand that. That is why I raised it. I left that till last. I didn't understand.

We are not far away from where—and I assume your testimony overall has suggestions for the changes that you think ought to be made.

Mr. McCOLLAM. Yes, it does.

Senator WIRTH. Terrific.

Let me jump to you, if I might, Mr. Wiel. You said, if this is a correct quote, 49 of 50 states penalize energy efficiency. Is that right?

Mr. WIEL. That is what I said, yes.

Senator WIRTH. How does that happen? Is that because there aren't very many effective state regulatory utility commissioners, or how does that happen?

Mr. WIEL. I would like to think that that is not the cause.

Senator WIRTH. Tell me how that happens.

Mr. WIEL. What has happened is this. Since the early part of this century, the ratemaking formulas that have been used by state regulators have rewarded two things. They have rewarded investment in new power plants and, in fact, investment of any capital, but it has traditionally been in power plants. And secondly, they have rewarded finding productive new uses and increasing the sales of electricity. And that is all it has rewarded. Nothing else.

Since 1970—excuse me—up until 1970, that reward was consistent with our societal goal because we wanted to expand the use and network of electricity, provide it to all people and as much as they wanted.

Since 1970, since the price of electricity has been increasing, there has been one other thing we would like to achieve, and you have been listening to it here today and you have been aware of it for several years I know, and that is that we would like to improve the efficiency with which we use our energy. The ratemaking formula still does not address that. What we do—

Senator WIRTH. Who sets the ratemaking formula?

Mr. WIEL. State regulators.

Senator WIRTH. Well, why don't you guys change it then?

Mr. WIEL. We haven't changed them and we should.

Senator WIRTH. If that has been a verity since 1970, it is now 1989.

Mr. WIEL. Come speak to the Conservation Committee. It is only within the last year—

Senator WIRTH. What is the problem with doing that? If it is as obvious as it is—and Mr. McCollam seems to think that makes sense and everybody that has testified all day long seems to think that—why doesn't it happen? Am I missing something in this? What is the reason it doesn't happen?

Mr. WIEL. I can answer that in two ways. I could answer why it hasn't happened, and I can answer that I hope that it will happen.

The Conservation Committee of NARUC, starting about a year ago, has mounted a campaign to promote within state commissions changing the ratemaking formula.

Senator WIRTH. Tell me what are the pressures that cause that not to happen. If everybody, as you suggest, starting in 1970, said we ought to do that, and then you get to 1988, we have an 18-year period of time. Who was against it? Mr. McCollam's people weren't against it, were they? Who was against it?

Mr. WIEL. I think what you are finding is the lethargy in the system. It is probably about the same as asking why are there still incandescent light bulbs on our ceiling here. What happens is that a public utility commissioner has—

Senator WIRTH. It has taken us a year to change those.

Mr. WIEL [continuing]. A charter of protecting to the consumer the lowest possible rates for a reliable source of energy. And there is a balance there. And, of course, the politics has changed within the—

Senator WIRTH. Who was on the other side of this in 1970 or 1976 or 1982? If you say that—what are the politics on it?

Mr. WIEL. Bottom line public pressure within the states, the state regulator to keep rates low.

But what I am proposing and I will be proposing in Nevada to my fellow commissioners is that we add a term to our ratemaking formula to allow utility companies to make more money than they have been making in the past. You can understand why that would be considered locally a somewhat sensitive issue that I want to take money away from the consumers in this country in the short term, the consumers in Nevada, and I want to give it to the utility companies. And I want to do that because if I do it in the short run, I believe in the long term, those utility customers are going to have lower bills. But it is going to take a campaign to change the psychology.

Senator WIRTH. Dr. Robertson and Ms. Hickey, maybe you can help me out. Why do 49 of 50 states penalize energy efficiency and why is it so difficult to reward rather than to penalize energy efficiency?

Mr. ROBERTSON. Largely because they aren't after energy efficiency. They are after conservation. If you are after energy efficiency, then what you do is you simultaneously provide the incentives that Commissioner Wiel talked about to save energy, make overall—make the same amount of capacity go further. And then you provide utilities with the flexibility to make sure that capacity gets utilized.

If you don't do that, if you don't balance that equation, then what you have is—what he has is a double cost hit. He has the cost of conservation, and he has the cost to the consumer of reducing the volume of sales over which he is spreading his resource cost which includes the conservation cost.

So, I suspect that as long as NARUC has a conservation committee, as opposed to an efficiency committee, the economics will never quite work.

Mr. McCOLLAM. Could I add something to that?

Senator WIRTH. Please, Bill.

Mr. McCOLLAM. Electric utility ratemaking is an extremely complex affair. And you have to have some flexibility in that ratemaking process to adjust to the local circumstances, the type of load you have, the nature of the system and so forth. It is extremely complex. You just can't generalize the way we are trying to do here.

The second point I would like to make is that I certainly wouldn't agree with Commissioner Wiel that there have been very many economic incentives lately to build anything. I think it is quite the contrary. I think there are not economic incentives to build anything. The utilities, in fact, have every incentive not to build, and this is one of the problems we are dealing with now.

Now, there has to be a reasonable balance between the things we are talking about here—that is, promoting energy efficiency, and the industry is 100 percent for that. But even with all the steps that can be taken—and this is where I think I differ and our industry would differ in view from some of those already expressed—you are going to have to be building something in addition to it. I don't think there is any question about that. That can be fairly well documented.

But we should proceed to improve energy efficiency at every turn, shape our loads so that we can achieve the most efficiency in

the production and the utilization of energy. But we are going to have to have some economic incentives of some kind to build new capacity or we are going to be in trouble.

Senator WIRTH. I appreciate that.

Going back to the conservation side, Dr. Robertson, in looking at the success that you all have had, clearly you and Ms. Hickey are here telling us of a successful utility venture in conservation. Right? That was the story that the two of you were telling in a very compelling way.

Mr. ROBERTSON. At least part of it, yes.

Senator WIRTH. Now, why doesn't that get—and this is another way of asking the questions that I have been asking of Mr. McCollam and Mr. Wiel. Why doesn't what you have done get repeated to the other utilities? Forty-nine of 50 states penalize efficiency says Mr. Wiel. Why is what you have done not repeated elsewhere? Or maybe it is.

Mr. ROBERTSON. We serve in seven of the states, so in six of them at least we must be getting penalized.

It has been possible for us to manage as one company with a little more flexibility over the last several years because we have found large efficiencies in our system overall that have enabled us to reduce costs and hence prices on average to our customers.

With that trend in our system, we have had the flexibility from many of our regulators to try different approaches to the energy saving/energy efficiency equation. We have been allowed to experiment. We think we have benefited, and we think the people we serve are benefiting as well over time.

That is not a very good answer to your question, but I think in fact it is the reason why we have been able to experiment pretty successfully.

Mr. MCCOLLAM. Could I make a comment here? You didn't ask me about the economic disincentives.

I wouldn't agree with Commissioner Wiel that those economic disincentives are out there on as grand a scale as he seems to be suggesting. We would not have accomplished what we have already had there been all these economic disincentives.

I think you have to have maximum flexibility without being prescriptive, and particularly at the state level, in each one of these individual situations to promote energy efficiency. The record shows we have, in fact, done that.

Now, admittedly there is probably a lot more that can be done, but I don't think as a general statement it is true that there are that many economic disincentives to promote energy efficiency as opposed to conservation which means denial of use to me.

Ms. HICKEY. I should also mention just for the record that Bonneville does not have its rates reviewed by a state regulatory commission. Our rate-setting is reviewed by the Federal Energy Regulatory Commission. And basically we set our rates to assure that we recover our costs and repay the Federal treasury. So, our bottom line is not driven by rate of return on capital investment in same way that a private utility would be, which makes our case somewhat unique in this discussion.

Senator WIRTH. Mr. Wiel?

Mr. WIEL. I think we are seeing a couple of things here. First of all, the distinction that Mr. Robertson is making about conservation versus energy efficiency is not one which we make in the Conservation Committee of NARUC. And we would consider ourselves the same thing whether we were called the Conservation Committee or the efficiency committee, and I wouldn't care which we were called.

The point is we are not asking people to sacrifice. We are talking about getting more use out of a Btu of carbon production or any other source of energy as we can, as many Btu's as we can.

Putting that aside, let's talk for a second about the pressures that are on the utility executive when the utility executive is making investment decisions. It is not simply a matter of economic pressures, and I am certainly not meaning to imply that the penalty I am referring to is enough to keep utility executives from making investments on the demand side into improving energy conservation. But there are other forces at work too.

First of all, there is the risk of investments on the supply side, and that risk has been huge since the late 1970s when my fellow regulators have been disallowing especially investments in large nuclear power plants. So, for that reason the executives may be scared away even more from supply side investments than they are from demand side investments. No question they have to do something to provide electricity and avoid brown-outs and black-outs.

But then there is one other factor, and that is that there is no question that utility executives know that they are better off if they please their regulators than if they don't. And there are many of us all around the country that have been putting pressure on our utility companies to perform on the demand side.

And in Nevada we have been doing that. Nevada Power in the south and Sierra Pacific in the north have achieved over the last roughly five years approximately 7 percent reductions in demand by their activities, and that is all well and good. And they are doing it not because they are making a profit from that activity, but because they are scared of the supply side investments—and we are in a high growth area, and they would have to do them otherwise—and because we want them to.

The point is that I would guess that the cogeneration industry 10 years ago would have argued, hey, we are doing a lot in cogeneration. And along came PURPA, and looking back on it, they were doing almost nothing compared to what they could have been doing.

And I believe that if we lay on the table the opportunity for the utility companies not just to recover their expenses—and these days that seems like a pretty safe way for them to be treated. If we can recover our expenses, the threat goes away and we are doing well. If we, in addition to letting them recover expenses, in addition to allowing them to earn a return on their capital investment which is moving in the right direction, as The Alliance to Save Energy study shows, if in addition we counted how much they provided to society in benefit above and beyond their investments on the demand side, and we allowed them to make a profit on that benefit that they provided, I think we would see an order of magnitude or two orders of magnitude increase in the enthusiasm and ac-

tivity that utility companies are providing. We are asking the utility companies to enter into a large, new industry that at this point I would say they are only dabbling in.

Senator WIRTH. I just don't understand this, Mr. Wiel. Maybe I am slow and I will get you all to fill me in afterward. But if that is the case, why don't you do it?

Mr. WIEL. We are——

Senator WIRTH. It seems to me——

Mr. WIEL. I am trying.

Senator WIRTH [continuing]. If Mr. McCollam's utilities can make money by doing conservation—everybody agrees that conservation or efficiency, or whatever we want to call it, is important—why don't you redesign utility rate structures so that they can make money doing conservation or efficiency? I understand that probably writing the regulations and defining the agenda is difficult. I understand that.

Mr. WIEL. It is really a matter of gaining the political momentum to do it.

Senator WIRTH. We want to help. We are here to help you.

Mr. WIEL. And I hope so. And we are here to help you in getting the political momentum to get your bill through.

Senator WIRTH. I think we have probably beaten this horse enough unless you all have some words for the good of the order in closing this operation.

I think this has been a very interesting afternoon, and I not only thank you for your great patience in waiting through the morning of what has been a long day. This is an enormous topic, as we all know, and we have to do the best we can given the Senate schedule to climb through as much material in a day as possible. But you all have been both very patient and very helpful. And we thank you very much.

The record will be left open, as you know, for questions from the committee or individual members. And we look forward to hearing—Mr. McCollam, we'll go back through the specifics of your testimony, in particular, those items which you think we ought to be changing. I don't get a sense that there are enormous disagreements between EEI and what we are trying to do here. I think that is a fair summary.

Mr. MCCOLLAM. I think that is a fair statement, but the points I have made I think are extremely important.

Senator WIRTH. I understand.

And, Mr. Wiel, we would like to get as clear a sense as possible of what we should be doing in here that helps you get this done to reach a goal that everybody all day long has said we ought to be doing.

So, to all of you, thank you very much for coming. We appreciate your being here.

The committee will be adjourned. Thank you.

[Whereupon, at 3:28 p.m., the hearing was adjourned.]



APPENDIXES

APPENDIX I

Responses to Additional Questions

Senate Energy Questions: J. Gibbons

QUESTIONS FOR JACK GIBBONS

- o You mentioned in your testimony that OTA is preparing a report on the role of existing and new energy technologies in slowing global climate change. Can you share with the committee now, or in writing, and of the preliminary results of your study as they relate to energy efficiency or renewable energy? It is important that the committee begin to get an idea of what contribution these technologies can play in our energy future and as part of a global warming strategy.

OTA's assessment on "Global Climate Change" is scheduled to be completed in August. We do not have any results beyond those provided in my testimony, but we will be happy to keep the Committee staff up-to-date on our progress. We have held several small workshops addressing energy efficiency in buildings and transportation, and are now reviewing a number of contractor reports and in-house staff analyses upon which our findings will be based.

- o On page 5 of your written testimony you stated that the track record of public policies designed to accelerate the shift to a more energy-efficient economy has been mixed. Can you cite some of examples of public policy initiatives that have been successful in this regard? What about those that have not worked?

It is easy to correlate a wide variety of energy policy legislation of the 1970's and 1980's with improvements in energy efficiency and commercial development of alternative energy technologies. It is very difficult, however, to demonstrate a causal relationship and very little data or analysis exists to evaluate the energy savings resulting from participation in such programs established by this legislation compared to non-participants. Nonetheless, many analysts feel that policies that established standards for

Senate Energy Questions: J. Gibbons

new appliance efficiency as well as policies to enhance the information available to consumers so that they could make informed choices were very effective. Some policies' effectiveness varied dramatically by region. For example, the Residential Conservation Service succeeded very well in a few states and not in others.. Similarly, the Public Utility Regulatory Policies Act (PURPA) coupled with the Federal and state renewable energy tax credits created a boom in renewable energy technology in California and not much anywhere else. A number of studies indicate that in many states financial incentives, e.g., the residential conservation and renewable tax credits, were taken advantage of but did not influence behavior very much.

- o I am a bit confused about the statement in your testimony about the lull in commercial development of solar thermal energy. Several weeks ago, The Washington Post ran a story about the expansion of a 200 megawatt power plant in California operated by Luz Industries. That's power hooked into the utility grid in Southern California. Can you clarify this for me?

The Luz Industries solar-thermal electric facility is indeed an example of a successful solar thermal electric project. Nonetheless, it is the only example for this technology and it serves as an important lesson. The Luz commercialization approach includes active participation with an equity position in commercial projects rather than simply delivering technology. This has been a key to successful early commercialization in wind, geothermal, and photovoltaic technologies as well, but with many more applications and variations in those technologies. The Luz projects have been the only successful commercial solar thermal technology applications to date and these projects have succeeded partly because of the Luz commercialization effort and partly because their version of the technology, a small scale,

Senate Energy Questions: J. Gibbons

modular parabolic trough, is well suited to today's power generation industry. By contrast, the commercial scale of many other variations of solar thermal are large, central station designs that are not very well suited to either small-scale demonstration or early commercial development projects, at least in the current power generation market.

- o Finally, you mentioned in your testimony that investors and regulators appear to lack sufficient information about these kinds of technologies. Are you aware of any programs at DOE or elsewhere to improve this situation?

I believe I was referring primarily to new power generating technologies and their applicability to a wide variety of specific utility circumstances. Commercial demonstration programs are very important to conveying information about applying such technologies in a specific area. When they have been carried out, e.g., the Coolwater integrated coal gasification combined cycle demonstration in California, they have gone a long way toward educating regulators, investors, and the utilities' themselves about the technology.

- o I understand that experts agree it is unlikely that solar thermal and other technologies will displace significant amounts of fossil fuels for baseload electric generation plants in the near future. In your opinion, will these new technologies ever completely displace fossil fuels in electric generation plants? If so, how soon will the displacement occur? Do you envision a phase-in period for the new technologies? In your opinion, is there an opportunity for fossil fuels and these various new technologies to operate side-by-side?

Yes, of course, new energy technologies will eventually prevail as fossil resources become too expensive to recover economically. But this is not likely to occur for a very long time -- perhaps a century or more. But, ultimately we will exhaust the supply of economically recoverable fossil

Senate Energy Questions: J. Gibbons

resources. We will have to develop alternatives which could include nuclear fission and fusion and renewable sources. The displacement will probably occur very slowly over many decades, even if it commences on an accelerated scale very soon. At the current rate of development, significant deployment of renewable power generating technologies are not likely to occur until well past the 1990s. For many decades renewable and fossil technologies will operate side-by-side, sometimes even together (as in a current configuration of solar thermal parabolic troughs assisted by natural gas firing).

- o I understand that renewable energy technologies will gradually assume a larger share of our nation's energy mix and that the eventual replacement of conventional fossil fuels by newly-developed energy sources may occur at some point in the future. However, as the coal industry is a large contributor to the economy of Kentucky and accounts, Directly and Indirectly, for about 70,000 Jobs in the state, I'm sure you understand my concern over any discussion of displacing coal. Do you know if any analysis has been done on the national economic impact of displacing coal as an energy resource?

I do not know of any comprehensive analyses of the impact of displacing coal as an energy resource.

- o In your opinion, will these new technologies create jobs and contribute to the economy at the level that oil, natural gas, and coal do currently?

The jobs created by these technologies will be quite different from those associated with recovery and utilization of fossil fuels, primarily because the heart of the economic activity associated with energy efficiency and renewable energy is the technology rather than resource recovery, refining, transportation, etc. (with the exception of biomass which is, of course, resource recovery intensive). Further, it is very difficult to make this comparison since, for example, investing in energy efficiency contributes

Senate Energy Questions: J. Gibbons

to the economy without significant direct external costs like environmental pollution. Hence, as the societal pressures placed on these external costs continually increase and as reserves economically of recoverable fossil energy resources become depleted, the services currently provided by fossil fuels will be replaced by alternatives. Since renewable energy is more technology intensive than resource intensive, many of the resource recovery jobs may be replaced by jobs requiring more technology skills and are less likely to be linked to regions with mineable fossil energy resources.

- o We will hear testimony later in this hearing which indicates that in 1988, less than 8% of the world's carbon dioxide was emitted by the U.S. Electric Utility Industry and that if this 8% were reduced to zero, it would have the impact of slowing the estimated time frame for a doubling of carbon dioxide in the atmosphere by 3 to 5 years. In light of the fact that the time frame for doubling atmospheric carbon dioxide is estimated to be 50 to 100 years, some might say that Immediate and Extreme action to reduce utility carbon dioxide emissions at the expense of the coal, oil and natural gas industries is unnecessary. What is your opinion? Do you think the actions called for in this bill are extreme?

The concern is not so much the accumulation of carbon dioxide itself but, rather, the relationship of this accumulation to global climate change, specifically warming known as the greenhouse effect. There is some evidence that dramatic reduction in greenhouse gas emissions (including carbon dioxide) will be necessary to slow global climate change, the impacts of which if not abated could be devastating including rising sea level, water shortages, etc. Hence, while it is true that some analysts consider committing to immediate and extreme actions to reduce emissions premature, others consider even dramatic steps like ceasing of all fossil fuel burning as essential. Hence, in light of the profound uncertainty, strong analytical support does not exist

Senate Energy Questions: J. Gibbons

for decisive policy action and it is likely to remain this way for some time, at least until we understand the greenhouse effect better. Nonetheless an important point not to be overlooked is that many of the steps that might be undertaken to reduce greenhouse gas emissions make sense for other reasons as well (such as energy efficiency improvements for improving energy security and international competitiveness or reducing local air pollution), and that even as the uncertainty surrounding global warming is addressed, such steps could be worthwhile for those reasons.

- o It seems that recent EPA policy decisions with respect to plant renovation will stifle installation of new, more energy efficient technologies in industrial settings. (See letters from Lee Thomas (October 14, 1988) and Don Clay (February 15, 1989) to John Boston of Wisconsin Electric Power Company). What are the ramifications of this for the deployment of new, more efficient technologies?

EPA policy decisions regarding life extension of power generation and other industrial fossil fuel burning technologies could have a substantial impact on the commercial deployment of new, more efficient technologies. Facilities can currently avoid the requirement of meeting New Source Performance Standards (NSPS) -- which normally involves installation of a costly stack gas scrubber -- if life extension investments fall below a specified fraction of the cost of a new facility. For power generation equipment, a rule of thumb threshold level is fifty percent of the cost of a new boiler which provides a considerable incentive for life extension investments. Indeed, the opportunity to be exempted from the NSPS afforded by this regulation has been the principal reason for the massive utility industry investment in life extension of existing facilities. The opportunity to

Senate Energy Questions: J. Gibbons

invest in life extension also precludes the need to invest in new, more efficient technologies, although the overall net effects on efficiency for any individual utility may be unclear. We cover this subject in some detail in the 1985 OTA report New Electric Power Technologies: Problems and Prospects for the 1990s.

- o What will be the net effect on global CO₂ emissions as a result of the widespread use of energy efficient technologies and renewable energy resources by the United States and other developed countries, without Third World cooperation?

In the short term such a scenario would address a large portion of the existing world CO₂ emissions. In the longer term, however, the growth rates of population and of fossil fuel consumption (and, hence, CO₂ emissions) are considerably higher for developing countries than for developed countries. Hence, the major growing sources of CO₂ emissions would not be controlled. Any effective strategy for dealing with global emissions reduction must address both industrialized countries and the LDC's.

* * *



Natural Resources
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April 4, 1989

J. Bennett Johnston
Chairman
Committee on Energy and Natural Resources
Washington, D.C. 20510-8150

re: Supplemental Questions from March 14 Hearing

Dear Senator Johnston:

Your letter of March 24 poses three questions, which follow up on the Committee's March 14th hearing on energy efficiency, conservation and renewable energy technologies (S. 324). The questions and my responses are set out below.

1. Much of your testimony has concentrated on things that we can do to achieve efficiency -- I'm interested in knowing what we can get from efficiency in terms of CO2 reductions and in reduced demand for energy. You indicated that NRDC has developed some preliminary studies on the potential of energy efficiency to reduce CO2. To achieve the results -- 15 percent reduction in CO2 emissions by the year 2000 -- what kind of economic costs are involved for the federal government and/or the private sector?

The energy measures outlined in my testimony would be less costly than the energy supplies that they would replace, so the economy would realize savings instead of costs. References on the dollar savings for particular sectors can be found throughout my testimony, its attachments, and a forthcoming NRDC article in the April 1989 issue of the World Policy Journal (R. Cavanagh, C. Calwell, D. Goldstein & R. Watson, One Last Chance for National Energy Policy). NRDC has not yet tried to calculate the magnitude of the overall dollar savings; of course, that would be an immediate concern of the national least-cost plan set out in Title I of S. 324. Our measures would qualify for that plan only if they were part of the "least-cost" mix for meeting national energy and environmental goals; we ask only for a fair competitive opportunity. We do not expect or seek expanded federal energy subsidies, but rather an alignment of current

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J. Bennett Johnston
 April 5, 1989
 Page 2

federal energy budgets and regulatory authorities with least-cost principles.

2. You mentioned that investors lean toward investments in production facilities and not efficiency. Do you believe that a better base of information about efficiency and other alternatives would improve investor decision-making, as Dr. Gibbons indicated? Are you aware of any programs on the state level to ensure that this happens?

The question over-simplifies Dr. Gibbons's position; his and my testimony agree that the potent market barriers to efficiency go well beyond inadequate information. Certainly consumer education can help, but it is no complete substitute for, e.g., power supply auctions in which conservation entrepreneurs are allowed to compete on equal terms with power plant sponsors. Years of selective tending by taxpayer- and ratepayer-funded institutions have produced a well-developed infrastructure for energy production investment, which as yet has no counterpart on the efficiency side. If the dice are loaded against you it isn't enough to get an improved view of the table.

Nonetheless, I am encouraged that many states are moving to promote better information about efficiency opportunities. For example, my testimony notes the Electric Power Research Institute's conclusion that least-cost planning initiatives are moving forward now in no less than 43 states; advertising and public education are often integral to the efficiency programs that emerge under those initiatives. A good example is the Pacific Northwest's regionwide media campaign on energy-efficient home design, which is funded by electric utilities. The federal government could make an immediate, nationwide contribution to consumer awareness by upgrading the Department of Energy's shamefully neglected appliance efficiency labelling program. In general, those labels currently are obscure, obsolete and misleading.

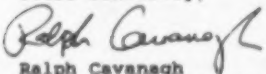
3. Your testimony indicates that least-cost planning is underway in 41 states, and yet you indicated that state regulatory systems usually make selling electricity more profitable than saving it. Why is it that states have not incorporated this principle into least-cost planning procedures?

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Page 3

The regulatory barriers described in my testimony are a completely unintended consequence of seemingly innocuous (and almost universal) ratemaking techniques. Most states were not even aware of the issue until recently; it simply did not surface before 1987-1988 on regulatory agendas outside California. The National Association of Regulatory Utility Commissioners took official note of the problem in July 1988, however, and responses are already underway in Washington, Oregon, Wisconsin, Minnesota, Massachusetts, Maine and New York (to cite just states that have recently requested my views on solutions). I am confident that the issue will be resolved satisfactorily once it gets onto state regulatory agendas, which is why I support the approach of S. 324. The bill simply requires states to consider adopting solutions within two years, drawing on earlier statutory precedent for unintrusive federal promotion of overdue state regulatory reforms.

Thanks again for the opportunity to appear before your Committee.

Yours sincerely,



Ralph Cavanagh
Senior Staff Attorney

QUESTIONS FOR TOM BATH

I. Dr. Bath, I want to commend you on your excellent testimony. SERI is a source of great pride and importance for Colorado and once again you have demonstrated that SERI is out front in thinking about a new energy future. I want to ask you whether there are any comparable analyses that integrate energy and CO₂ reduction strategies?

There have been many studies which explored the projected results of response options to mitigate greenhouse gas emissions. Not surprisingly, most have focussed their attention on energy supply and demand. Examples are Jäger (1) Goldemberg, et. al. (2), Mintzer (3), Edmonds, et. al. (4), and Lashof and Tirpak (5). One interesting exception is Marland (6), which explores reforestation possibilities. With the exception of Edmonds, these studies are global in scope and thus are not comparable to the SERI preliminary analysis which examines the U.S. contribution exclusively. The Edmonds, et. al., study does constrain itself to the U.S. situation, but it does not explore the economic implications of responses (restricting itself to technical feasibility instead) nor does it consider the use of renewable energy as part of the response. Thus, the unique aspects of the SERI preliminary analysis described in my testimony is that it seeks to apply the constraint of economic neutrality to the U.S. situation (an initial step in the assessment of economic implications) and that it incorporates elements of the three major response categories--efficiency, fuel substitution, and alternate energy. Intense effort is being devoted to this topic at the present time by both private and public sector analysts. The results of this work--for example, the DOE reports to Congress (which SERI is supporting)--should further illuminate the range of domestic and global response options as well as their economic implications.

1. Jäger, Jill. Climate and Energy Systems. J. Wiley & Sons, 1983.
2. Goldemberg, José, Thomas B. Johansson, Amulya K. N. Reddy, and Robert H. Williams. Energy for a Sustainable World. World Resources Institute, 1987.
3. Mintzer, Irving M., A Matter of Degrees: The Potential for Controlling the Greenhouse Effect. World Resources Institute, 1987.
4. Edmonds, J. A., W. B. Ashton, H. C. Cheng and M. Steinberg. "A Preliminary Analysis of U.S. CO₂ Emissions Reduction Potential from Energy Conservation and the Substitution of Natural Gas for Coal in the Period to 2010." DOE/NBB-0085, February 1989.
5. Lashof, D. A. and D. A. Tirpak. "Policy Options for Stabilizing Global Climate (Review Draft)." Report to Congress, U.S. Environmental Protection Agency, February 1989.
6. Marland, Gregg. "The Prospect of Solving the CO₂ Problem Through Global Reforestation." DOE/NBB-0082, February 1989.

2. You mentioned in your testimony that one of the critical components of efforts to reduce greenhouse gas generation is government leadership. Could you elaborate on that and comment on whether you are aware of any efforts at DOE or elsewhere to provide that leadership?

It is my feeling that, given the intangible nature of global warming, sustained leadership--likely from government--will be needed to motivate our society to adopt responses which take account of these concerns. This Bill and this hearing are an example of such leadership. I feel that we are seeing evidence of determination to provide such leadership both in the Congress and in the Executive Branch. Examples of the latter are the remarks of Secretary Baker to the IPCC and the commitment by Admiral Watkins to build an appropriate response to these concerns into the next National Energy Policy Plan and the associated implementation strategy which he intends to develop. Such leadership can be programmatic as well as philosophical. Here again, government and private sector analysts are working these issues vigorously and will identify a full panoply of options in the near future. Examples might be information programs, enhanced R&D programs, programs to influence government energy use, programs to provide technical assistance to government organizations or state regulators, even programs for the development of performance standards, or other regulatory programs.

3. The second scenario developed in your study assumes that "cost effective" conservation measures are adopted to a reasonable extent by energy consumers? Can you define reasonable extent and comment about whether or not incentives could be developed to encourage efficiency to be adopted beyond this assumption?

The terminology in my testimony paraphrases that of the DOE Energy Conservation Multi-Year Plan. A more extensive quotation from that Plan is: "...savings above current trends (emphasis added) that could be obtained should consumers adopt, at modest levels, currently available cost-effective technologies and anticipated technologies that are still under development."

Market penetration of any new product or technology is influenced by a variety of factors beyond cost-effectiveness. These include capital turnover schedules, consumer preferences, perceptions of future values, and inherent resistance to change. Generally speaking, any product which achieves 70% of its economic potential over a ten-year period should be considered an unqualified success. The Conservation Multi-Year Plan projects nearly 60% penetration of these products leading to a substantial (16.2 quad) reduction in energy demand against the base case. The SERI study attributes this high level of penetration to "government leadership" and uses the term "reasonable extent" based on our view that the DOE intended to be optimistic, but reasonable in its projection of market penetration.

4. On page 14 of your testimony, you note that activities to support investor confidence can also pay dividends in the adoption of renewable energy technologies. If the federal government were to put a premium in this area, what kinds of things should it be doing?

Such activities would reduce the perceived risk of investors in either participating in research or technology development programs or in building facilities which would utilize or supply evolving renewable technologies. There are a wide variety of possibilities, both on-budget and off-budget which might work to this end. They range from R&D tax credits to information and technical support to those considering investments to multi-year funding for long-term technology development activities or even cost-shared demonstration projects to reduce uncertainties, as we have in today's "clean coal" programs.

5. Finally, I want to ask you whether or not you believe there are any renewable energy technologies that deserve more attention at present. Is there a priority research area?

In my opinion, all of the renewable (and conservation) technology programs would return substantial benefits, if their activity levels were enhanced. In the case of renewables, two generic points are worth mention: (1) the present program has no effort directed toward bridging between basic research and technology development--an analogue to the ECUT program to address cross-cutting research needs could pay dividends, (2) it might be appropriate in enhancing program vitality to support a set-aside for new initiatives within the overall renewable energy effort in a manner similar to that described for energy efficiency research in Section 302(a) of the Bill. More specifically, in the context of a world-wide response to global warming concerns, it is my opinion that the biofuels and photovoltaic technologies deserve special attention because of the widespread availability of the resources on which they depend--enhancing the potential for energy self-sufficiency of most developing nations.



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From: Dr. Arthur H. Rosenfeld, Director
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To: J. Bennett Johnston, Chairman
U.S. Senate Committee on Energy and Natural Resources
Washington, DC 20510-6150

Re: Answers to questions from Committee Members (questions attached)

1. Large savings are possible in both residential and commercial buildings if sufficient funding is made available for R&D. Buildings account for over 65% of electricity use, and over half of this is for residential buildings. During the next 20 years space cooling and lighting are expected to grow by over 50%. Since 1980 energy efficiency R&D has been cut to the bone. Existing R&D at DOE is well balanced but funding needs to be expanded.
2. The technical potential available today can reduce total energy use by 50%. Over 20 years this would translate to an improvement in energy efficiency of 3.5% per year. This is both achievable *and* affordable with less than 3-year paybacks. Compared to new sources of supply—power plants, oil wells, or imported oil—improving energy efficiency by 50% has a *negative* net cost. However, if economic growth continues at 2.5% per year we will need to keep reducing energy use by 3.5% per year for the next 70 years to get energy use down to 50% of current use. This will take an investment in R&D if new technologies are to be made available.
3. We can achieve a 3.5% per year improvement in energy efficiency *and* avoid structural change. From 1973 to 1986 GNP grew by 35% and energy use stayed constant. This translates into a 2.5% per year improvement in energy efficiency. We estimate that two-thirds of this was due to improved energy efficiency, and one-third was structural change (i.e. increased imports of oil, steel, cars, etc.). Also remember that OPEC had control of world oil prices

April 6, 1989

A.H. Rosenfeld

during the oil crises of 1973 and 1979. In order to achieve a 3.5% per year improvement we must have a national energy policy that would include:

- increasing funding for energy-efficiency and renewable energy R&D,
- setting standards for improving energy efficiency in transportation, buildings, and industry,
- re-evaluating the standards as R&D produces new technologies,
- supporting least-cost utility planning programs,
- requiring more extensive energy labeling for products, and
- establishing minimum price levels for oil to more accurately reflect the true cost of depleting future reserves.

A national energy policy would provide insurance against another oil crisis, assure more adequate supplies of energy resources for future generations of Americans, reduce the threat of global warming, and help create a sustainable energy future.

4. In real terms energy efficiency R&D budgets are down by 30% since 1980. The Reagan administration asked for another 50% reduction in energy-efficiency R&D this year. However, the EPA is calling for doubling the efficiency of cars and buildings over the next 20 years. How long will it take to realize the inconsistency of asking for a doubling in efficiency and at the same time cutting the R&D budget by one-half? The net effect is that we are losing some of our best scientists and engineers due to budget cuts. We also aren't able to attract the brightest young scientists and engineers to work on improving energy efficiency. If this continues our R&D efforts will be seriously hampered.

QUESTIONS FOR ART ROSENFELD

1. If we want to enhance energy efficiency in the electricity sector, is there a priority for research and development efforts? In other words, where do we get the most bang for the buck -- in residential or commercial buildings and so on?
2. You stated in your testimony that you would like to see energy intensity improve by 3.5 percent a year. Is that achievable and if so, what are the costs associated with that kind of rapid improvement?
3. Let me ask you a related question, if we were to achieve a 3.5 percent improvement in intensity, what percentage of that improvement would you expect efficiency to contribute, and what role would structural changes in our economy play?
4. Finally, it is my understanding that many researchers at the National Labs are finding it difficult to fund projects on efficiency from DOE budgets. Consequently, many of our scientists are moving into consulting roles. What are your opinions about these developments and how do you affects our laboratory research programs.

The
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To Save Energy

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**RESPONSES OF JAMES L. WOLF
EXECUTIVE DIRECTOR, THE ALLIANCE TO SAVE ENERGY
TO QUESTIONS FROM THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES**

APRIL 7, 1989

Responses of James L. Wolf
Executive Director, The Alliance to Save Energy
to Questions from the
Committee on Energy and Natural Resources

1. In your testimony you commented on the bill's provisions relating to the development of Home Energy Rating Systems. Is there a role that DOE could take on now, prior to action on this bill, to help design these systems?

Answer: DOE could establish technical guidelines for home energy rating systems, help streamline mortgage financing programs to facilitate the use of rating systems, and help states implement rating systems. DOE can draw on its years of research and demonstration efforts related to home energy rating systems to develop the technical guidelines. It can convene a workshop involving lenders, builders, realtors and others to streamline the energy-efficient mortgage programs and coordinate rating systems with them. DOE can help states implement rating systems by conducting new demonstrations in one or more states, offering technical assistance to other states, and coordinating a publicity campaign operated by the shelter, energy, and financial industries.

2. One of the debates that is emerging in some circles is about the external costs of energy consumption. We have attempted in this legislation to begin examining incentive programs that will put energy efficiency on a par with supply-side investment decisions. Are these regulatory reforms going to help address the question of externalities?

Answer: Yes, I believe the amendments to PURPA contained in Section 311 of S. 324 will help address the question of externalities. Section 311 establishes a "least cost investment standard" for both regulated and nonregulated electric and gas utilities. Least cost is defined in terms of "the incurrence of lowest total costs to society, such costs to include ... environmental costs." State regulatory authorities and nonregulated utilities are directed to implement the least cost standard, provided that it is appropriate and consistent with applicable state laws.

In practical terms, the least cost standard means that regulatory authorities and nonregulated utilities must consider externalities, since the phrase "lowest total costs to society" certainly encompasses external costs. In addition to environmental costs, such costs might include, for example, effects on the nation's energy security and industrial competitiveness. While the quantification of externalities will certainly be difficult, the standard clearly establishes the principle that they should be accounted for.

Other provisions of S. 324 reinforce the point that externalities must be addressed in energy policy. Title I, which mandates the preparation of a Least-Cost National Energy Plan, specifies that "quantifiable environmental and national security costs and benefits" should be factored into the assessment of the total costs of energy resources. Additionally, this title directs that conservation resources be given a ten percent cost advantage in comparison with other resources. This ten percent advantage, which can be considered a partial and approximate means of adjusting for externalities, is modeled after a similar provision in the Pacific Northwest Electric Power Planning and Conservation Act (P.L. 96-501).

3. Finally, you indicated that many of the firms surveyed by the Alliance were concerned about the fact that a number of technologies that were researched and developed here are being commercialized overseas. What kind of responses did you receive from the private sector about solutions to this problem?

Answer: Our survey of firms engaged in energy efficiency R&D asked (among other questions) why many efficiency technologies developed in the U.S. are being commercialized overseas but not domestically. Survey respondents pointed to several factors:

- Higher energy prices and fewer indigenous energy resources overseas, which make efficiency investments more economically attractive.
- Lower labor costs abroad.
- The greater emphasis placed by overseas companies on production technology, rather than technical innovation per se.
- Cultural differences in management style, and greater willingness of overseas competitors to take risks and to accept lower near-term returns on investment while building long-run market share.
- Governmental assistance to help companies develop and capture global markets.

While we did not specifically ask survey respondents to suggest policies that could overcome these tendencies, several were suggested, including: large-scale government purchases of conservation measures that are economic on a life-cycle cost basis; expanded job training programs; and tax incentives to spur investment in efficient technologies. Running through the answers to all of our survey questions, however, was a clear call for greater federal support of

demonstration and commercialization activities. Industry believes that such support is needed to help fill the gap between the proof of a concept (where R&D funding often ends) and successful commercialization.

4. (from Senator Heflin) What will be the cost and expected benefit of requiring homes that are sold to be rated in terms of their energy efficiency? Will this make home ownership even harder than it is already becoming?

A: The home energy rating policy we support will make homes more affordable. While it may raise home prices slightly, this will not hurt homeownership, because energy bills will drop by a greater amount than the small increases in mortgage payments. The result will be housing that is more affordable.

For example, if a home is rated energy efficient, Fannie Mae, Freddie Mac and FHA policies will allow mortgage lenders to let buyers spend a larger portion of their income on mortgage payments, knowing that lower energy bills will let the buyer afford higher payments. This means energy efficient homes will be affordable at lower income levels than other homes.

For homes not currently energy efficient, owners seeking to sell their properties will be more likely to add energy efficiency features before putting their homes on the market. Since they know the home will be rated, the energy upgrades make it more marketable. While this may add to the sale price of the house, our experience is that the increase in mortgage payment is typically less than the reduced energy bill.

Finally, this policy lets buyers of existing homes roll the cost of energy efficiency improvements into their mortgages. If sellers are unable to make the improvements, buyers can bring contractors' estimates to the mortgage closing and have them financed in their mortgage payments. Again, there are many energy efficiency investments which will reduce energy bills by an amount that exceeds the increase in the mortgage payment.

The costs and benefits of a rating requirement are best shown by illustration. The cost of an energy rating varies; a typical figure used in the field is \$150 per home. This is about 1/10 of 1% of the national average home sale price. At current interest rates it would add about \$1.42 to the average mortgage payment.

The benefits for buyers of existing homes comes when they roll the cost of energy improvements into their mortgages. Taking the average 1987 existing home sale price of \$117,700, and assuming a \$3,000 cost for energy

improvements, rolling the energy improvements into the mortgage at 1987 interest rates would increase payments by \$24.05 per month. Typical investments of this magnitude can save \$35.00 or more per month (based on a payback period of seven years or less). Thus the homeowner winds up paying less overall to live in the home.

The benefits for buyers of new homes are in the form of easier mortgage qualifying. Homes rated energy efficient can be financed with a higher portion of the buyer's income. The average 1987 new home, costing \$136,100, required an average income of \$45,560. Assuming the same home had cost \$2,000 more when built to energy efficient guidelines, this same family would be better able to afford the home, because lenders would let them borrow more to cover the higher cost. They do this because the \$16.02 increase in mortgage payments is less than the expected monthly energy savings, typically in the \$25 range.

2. (from Senator Heflin) Who are the major members and contributors to the Alliance?

The Alliance is directed by a board of 22 leaders from government, business, utilities, consumer and professional organizations, and academia. We rely on two types of funding: "restricted" grants and contracts that support specific projects, and "unrestricted" contributions that provide general support for the organization. Major sources of restricted funding over the past year included the U.S. Department of Energy; Fannie Mae and Freddie Mac; Exxon Corporation; Pennsylvania Electric Company; and Northeast Utilities (among others).

Unrestricted contributions are provided by corporations, foundations, labor unions, and individuals. In 1988, contributions above \$10,000 were received from the John D. and Catherine T. MacArthur Foundation; IBM; BP America; and Chrysler. A total of 69 organizations and individuals supported the Alliance with unrestricted funds in 1988.

A complete list of sources of financial support for 1988 is attached.

SOLAR ENERGY INDUSTRIES ASSOCIATION

QUESTIONS FOR SCOTT SKLAR

1. Regarding Authorization Levels: While increases are necessary for solar and renewable energy research & development, the levels outlined in the Wirth Bill are appropriate levels to insure that the technologies currently in the research pipeline are commercialized before those of our international competitors.

2. Regarding DOE Management Interaction With OMB: My personal view is that OMB is biased against solar and renewable energy and holds these programs under a different standard than the conventional energy R&D programs. Changes in OMB management may now bring all energy programs in greater balance, therefore allowing DOE management to more adequately interface with the OMB process.

3. Regarding Solar Research Priorities: Some promising research that must be continued: Solar Buildings: Program integration that will allow U.S. industry to easily incorporate building advances in the marketplace including electrochromic glass, advanced passive and active solar storage technologies; Solar Thermal: Stretched membrane concentration on heat engines and for toxic waste destruction; Photovoltaics: Advances in thin film and concentrator photovoltaics as well as utility interface programs; International: Market development in the Pacific Rim.

4. Regarding the Payoff in Solar Research for Large-Scale Development: The program has already been responsible for over 200 megawatts of private-sector financed solar thermal power. Greater payoffs will be realized within five years with over 1,500 megawatts of solar thermal power and 250 megawatts of photovoltaic electricity all utility-interconnected. However, if the FY'90 research budget is cut, most of these solar advances in the U.S. utility system will be accomplished by our overseas competitors!

QUESTIONS FOR SCOTT SKLAR

1. You paint a pretty grim picture about the current state of our research efforts. The bill before this committee recommends stepped up research programs for renewable energy programs. Would you comment generally on the authorizations proposed in the legislation? Are they too low?

2. I'm pleased to hear that the industry believes that the DOE's solar research programs are very well managed. However, why is it that the same able management has been so unsuccessful in defending these programs at OMB?

3. Is there a priority research program for solar? Given the extreme difficulties in finding loose funds in recent budgets, would you recommend that any programs be singled out as particularly promising?

4. When do you believe our federal research program in solar energy will pay off in terms of cost-effective, large-scale supplies of solar technologies? Is it 30-40 years away or 5-10?

SOLAR ENERGY INDUSTRIES ASSOCIATION

QUESTIONS FOR SCOTT SKLAR

1. Regarding The Use of Solar to Displace Fossil Utility Generation: Solar thermal power has already begun to displace fossil utility generation with over 200 megawatts in California and another 500 megawatts to be constructed within two years. Solar water heating is already in one million U.S. homes and displaces a significant amount of fossil fuel generation. Photovoltaic will become the technology of choice for remote electric generation and grid extension into remote areas. This is the phase-in period for these new technologies which will provide extensive load reduction (solar water heating), peak and remote utility power (photovoltaic and solar thermal power), and utility baseload (solar thermal power) in the 1990's, if the United States allows the technologies currently with the research pipeline to be commercialized. These solar technologies will be utilized with conventional fossil technologies to provide peak power or to offset emissions of conventional fossil fuels to meet tougher environmental limitations.

In Regard to Solar Energy Displacing Coal: Solar energy technologies are as labor intensive as coal mining and utilization. The U.S. solar industry actively needs support of coal states to establish a climate for solar manufacturing and installation in these areas as a way to create jobs in this new industry. Greater use of solar energy maybe the only energy source that could utilize the jobs displaced as coal production is cut for environmental reasons. The U.S. Congress should promote solar industries in coal states by developing manufacturing and utilization incentives in coal states. Large-scale use of solar energy will create more jobs than oil, natural gas, or nuclear energy per unit of energy produced.

QUESTIONS FOR MR. SCOTT SKLAR
EXECUTIVE DIRECTOR
SOLAR ENERGY INDUSTRIES ASSOCIATION

ADDENDUM #1 OF YOUR WRITTEN TESTIMONY IS AN ARTICLE ENTITLED "SOLAR BREAKTHROUGHS CAN LESSEN GLOBAL WARMING AND BREAK DOWN TOXIC WASTES." THAT ARTICLE INDICATES THAT MOST EXPERTS AGREE IT IS UNLIKELY THAT SOLAR THERMAL AND OTHER TECHNOLOGIES WILL DISPLACE SIGNIFICANT AMOUNTS OF FOSSIL FUELS FOR BASELOAD ELECTRIC GENERATION PLANTS IN THE NEAR FUTURE.

WILL YOU DEFINE "NEAR FUTURE," AS IT IS USED IN THIS ARTICLE?

IN YOUR OPINION, WILL THESE NEW TECHNOLOGIES EVER COMPLETELY DISPLACE FOSSIL FUELS IN ELECTRIC GENERATION PLANTS?

IF SO, HOW SOON WILL THE DISPLACEMENT OCCUR?

DO YOU ENVISION A PHASE-IN PERIOD FOR THE NEW TECHNOLOGIES?

IN YOUR OPINION, IS THERE AN OPPORTUNITY FOR FOSSIL FUELS AND THESE VARIOUS NEW TECHNOLOGIES TO OPERATE SIDE-BY-SIDE?

I UNDERSTAND THAT RENEWABLE ENERGY TECHNOLOGIES WILL GRADUALLY ASSUME A LARGER SHARE OF OUR NATION'S ENERGY MIX AND THAT THE EVENTUAL REPLACEMENT OF CONVENTIONAL FOSSIL FUELS BY NEWLY-DEVELOPED ENERGY SOURCES MAY OCCUR AT SOME POINT IN THE FUTURE. HOWEVER, AS THE COAL INDUSTRY IS A LARGE CONTRIBUTOR TO THE ECONOMY OF KENTUCKY AND ACCOUNTS, DIRECTLY AND INDIRECTLY, FOR ABOUT 70,000 JOBS IN THE STATE, I'M SURE YOU UNDERSTAND MY CONCERN OVER ANY DISCUSSION OF DISPLACING COAL.

DO YOU KNOW IF ANY ANALYSIS HAS BEEN DONE ON THE NATIONAL ECONOMIC IMPACT OF DISPLACING COAL AS AN ENERGY RESOURCE?

IN YOUR OPINION, WILL THESE NEW TECHNOLOGIES CREATE JOBS AND CONTRIBUTE TO THE ECONOMY AT THE LEVEL THAT OIL, NATURAL GAS, AND COAL DO CURRENTLY?

WE WILL HEAR TESTIMONY LATER IN THIS HEARING WHICH INDICATES THAT IN 1988, LESS THAN 8% OF THE WORLD'S CARBON DIOXIDE WAS EMITTED BY THE U.S. ELECTRIC UTILITY INDUSTRY AND THAT IF THIS 8% WERE REDUCED TO ZERO, IT WOULD HAVE THE IMPACT OF SLOWING THE ESTIMATED TIME FRAME FOR A DOUBLING OF CARBON DIOXIDE IN THE ATMOSPHERE BY 3 TO 5 YEARS.

WHAT IS YOUR OPINION OF THESE ESTIMATES? ARE THEY ACCURATE?

IN LIGHT OF THE FACT THAT THE TIME FRAME FOR DOUBLING ATMOSPHERIC CARBON DIOXIDE IS ESTIMATED TO BE 50 TO 100 YEARS, SOME MIGHT SAY URGENT AND EXTREME ACTION TO REDUCE UTILITY CARBON DIOXIDE EMISSIONS IS UNECESSARY. WHAT IS YOUR OPINION?

SOLAR ENERGY INDUSTRIES ASSOCIATION

SENATOR HEFLIN QUESTIONS FOR SCOTT SKLAR

1. Paybacks and costs for all the solar technologies under the different markets and circumstances is very complicated, but again I have attached the cost and efficiency charts published by US/DOE and attached (see question 3) is a selection of solar applications costs data from a recent publication.

2. Regarding the Utilization of Strategic Metals: Solar energy technologies use more common metals such as aluminum and sheet metal, and glass and silicon. Minor use of silver for reflector membranes and wiring is used, as is copper. Use of these common metals and ores is no greater than conventional semiconductors, turbines, or HVAC equipment.

3. Regarding Solar Meeting Developing Country Needs: Solar is an ideal technology for the developing world which accounts that over 65 percent of photovoltaic technologies currently exported. Both solar thermal and photovoltaics are very appropriate for developing countries and I have enclosed the appropriate pages from a recent 1988 US/AID Publication: Renewable Energy In Agriculture and Health. The U.S. Export Council for Renewable Energy (US/ECRE), formed by the nine national renewable energy trade associations to promote exports of alcohol fuels, geothermal, hydropower, passive solar, photovoltaics, solar thermal, wind and wood energy, has been funded by the U.S. Department of Commerce to hold a renewable energy trade promotion event on May 30-June 3, 1989 in Miami to build the markets in the Caribbean Basin and Latin America.

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Questions for Scott Sklar
from Senator Heflin

1. Please rank the major solar technologies in terms of energy and capital payback and plot their efficiency and cost versus time. What are the probable limits of these efficiencies and costs?
2. What technologies utilize strategic metals and to what extent?
3. Do any solar technologies meet the needs of developing countries: low cost, small area requirements, useful energy form, and readily available materials?

PACIFIC POWER & LIGHT COMPANY

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William D. Robertson, Jr.
Vice President

April 7, 1989

The Honorable J. Bennett Johnston
Chairman
Senate Energy and Natural Resources Committee
SD364 Dirksen Senate Office Building
Washington, D.C. 20510

Dear Mr. Chairman:

Thank you for your interest in Pacific Power's testimony at the recent Senate Energy Committee hearing on the proposed National Energy Policy Act of 1989 (S. 324). We appreciate the opportunity to expand on that testimony in response to your specific questions.

Pacific Power's view of S. 324 and other legislative and regulatory initiatives affecting our industry is heavily influenced by our belief that the energy services marketplace is in a period of fundamental change. While that change has many facets, its most important element in our opinion is steadily increasing competition in the delivery of energy services to end use customers.

Competitive circumstances differ from one region of the country to another. In the areas Pacific Power serves, the energy services marketplace is characterized by increasingly intense competition between electric utilities and alternative energy service suppliers of several types. In bulk power markets, we compete with other utilities, with non-utility generators and with oil and gas which is used to fire our customers' incremental generating capacity when the price is right. In retail markets, we compete with suppliers of on-site generation and cogeneration service who are targeting our largest industrial and commercial customers, with alternative fuel suppliers for residential and commercial space and water heating sales, and with suppliers of technology whose products tend to reduce sales of utility system energy.

By our calculations, approximately 50 percent of our sales by volume are "at risk" in the short-to-intermediate term. And we believe the trend toward increased competition is accelerating.

The market uncertainty that results from this change poses tremendous challenges for those of us who have thought of ourselves as "natural monopolies." It means, among other things, that our traditional concern with supply side issues must be matched, if not exceeded, by a concentration on the demand side of our business.

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It means, in short, that we must become more businesslike in our operations -- more market-conscious and more customer-responsive.

The challenge to public policy makers that results from this change is equally daunting. The body of law and regulation that surrounds our industry today is the product of an era that is passing. As you and others have noted, it does not encourage innovation in the delivery of energy services to end users. Rather, it is focused on controlling an industry that was perceived to have near-total market dominance.

It is our belief that the evolution of our marketplace requires that we think in terms of "least-cost" solutions to energy problems -- both our own and our customers'. By the same token, we believe public policy initiatives such as S. 324 should be shaped in a manner that enables and encourages companies like ours to adapt to an increasingly competitive marketplace.

Responses to your specific questions follow.

- 1) Do you support the provisions of the bill that would require states to consider allowing utilities to maximize their profits to the extent that they adopt least cost plans?

Pacific Power believes public policy, including public utility regulation, should be structured to encourage the delivery of low cost, high value energy services to end use customers. Profit should be maximized when that result is achieved.

Least-cost planning tends to support such a result and, for that reason, we think it should be encouraged. It should be emphasized, however, that the production of a plan is not a substitute for production of results.

We do not envision a need for new resources in our system until the late 1990s. We are, however, developing "least cost" plans in response to requests from a number of our state utility commissions. In addition, we are purchasing "lost opportunity" resources, primarily conservation, which must be acquired as they become available. For example, our Pacific Plus marketing program provides builders and homebuyers with financial incentives to ensure that new, electrically heated and cooled homes are built to the highest efficiency standards.

We believe regulators should adopt policies which encourage utilities to implement conservation marketing programs. One way to do that is through provision of favorable allowed rates of return, such as is envisioned in S.324.

An equally important consideration, we believe, is the assurance

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of marketing flexibility. In an increasingly competitive marketplace, utilities must seek new ways to package and price energy and related products and services to meet individual customer needs. As regulators encourage utilities to adopt "least-cost" plans and develop such resources as conservation, they also should allow utilities to develop new approaches to selling both the conservation service and the resource acquired through it. The combination is necessary to ensure least-cost results for customers.

- 2) What is your position on the creation of qualifying conservation entities who would be entitled to sell conservation to utilities?

We believe such action is unnecessary.

Conservation is an attractive resource to utilities faced with uncertain market conditions. It allows additional "capacity" to be acquired in volumes that match new demand and, in so doing, reduces the financial risks associated with plant construction in an uncertain market environment.

Conservation services are available to utilities as well as energy end users through a wide variety of suppliers, including equipment and insulation manufacturers, controls system companies, builders, window makers and many others -- including some utility subsidiaries who have bid competitively to meet other utilities new resource requirements with conservation resources (e.g. Puget Energy Services).

Because conservation services are available in the marketplace, we believe creation of a new formal entity, the "QC", is unnecessary to stimulate conservation.

- 3a) What have U.S. electric utilities done over the last few decades to improve efficiency and promote energy conservation?

Many utilities, including Pacific Power, developed aggressive conservation programs in the 1970s in response to concerns about future energy supplies. We are particularly experienced with conservation among our residential customers, and are developing knowledge and experience in the commercial and industrial sectors.

Since 1970, Pacific has weatherized some 37,000 homes, for energy savings of 1.3 million kilowatt-hours. Our programs have included home energy audits, zero- and low-interest loans, weatherization rebates and cash payments, water heater wraps, heat pump marketing efforts, and many more.

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In addition, we have worked with other Pacific Northwest entities, including the Bonneville Power Administration, the Northwest Power Planning Council and other utilities to develop conservation programs for future implementation. The 1980 Pacific Northwest Electric Power Planning and Conservation Act directs that conservation -- cost-effective conservation -- will be the region's resource of first choice when the time comes for acquisition of new energy supplies, and we, as a region, are prepared to implement that provision of the law. We are currently involved in a regionwide effort to upgrade state and local building codes to incorporate energy efficiency standards developed by the Power Planning Council.

In short, conservation is an important component of our resource planning.

However, when considering resource efficiency, it is a mistake to focus entirely on end use. It is also possible, through 'upgrades and efficiency improvements, to extend the life and productivity of many existing generating plants.

Efficiencies can also be gained through greater coordination among regional power systems, and more use of seasonal exchanges between regions. A good example is the efficiency we gained through our merger with Utah Power. Because Pacific's system peaks in the winter while Utah's peaks in the summer, the combination of our two systems was like adding a new 400 megawatt plant to the system, without our having to invest in anything more than modest transmission upgrades. While we're not advocating mergers, we believe the industry should be encouraged to investigate how we can make better use of energy and capacity exchanges and, ultimately, get more out of the resources we already have.

- 3b) What changes in global CO2 emissions could be expected in 20 years if U.S. electric utility emissions were cut in half?

As we understand it, the U.S. electric utility industry is responsible for 8 percent of the world's CO2 emissions. Those emissions have remained steady since 1973 although the economy has grown some 40 percent. This is evidence, we believe, of increased efficiency in energy use.

It appears that cutting utility emissions in half would have relatively little effect on global emissions, especially in light of the growing role of non-utility generation in meeting electric energy demands.

It also indicates that only limited change in worldwide CO2 emissions can be expected from actions undertaken only by the United States.

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One answer is to help other countries develop alternative resources and incorporate energy efficiency products into their economies as they grow. The result will be less total global pollution and, at the same time, American industry will have established new markets.

As an example, Pacific has formed an integrated energy services subsidiary, ONSITE Energy, which offers both supply and demand technologies to increase customers' productivity. ONSITE believes significant opportunities exist in overseas markets for these services, but provisions of the Public Utility Holding Company Act make it difficult for many U.S. companies to participate in the development of new energy systems in those parts of the world where it is most needed. We believe a narrow amendment to the Act could remedy this situation.

In short, only through international cooperation and coordination, along with national policies which encourage energy efficiency and development of alternative energy resources, both in the U.S. and worldwide, can global CO2 emissions be meaningfully addressed.

That concludes my response to your questions. Please let me know if you would like any other information.

Sincerely,

Bill Robertson

RESPONSE FROM COMMISSIONER STEPHEN WIEL
ON BEHALF OF NARUC RE:
MARCH 14, 1989 GLOBAL WARMING HEARINGS
SENATE COMMITTEE ON ENERGY & NATURAL RESOURCES

Question 1: We appreciate your support of the provisions that link maximization of utility profits to the adoptions of least cost planning. You note that there are a number of ways in which this objective could be achieved by state regulatory commissions. Would you outline some of these alternatives to the Committee?

Answer 1: The NARUC Conservation Committee is currently studying five approaches to linking utility profits more positively to achievements in least cost planning.

1. Electricity Revenue Adjustment Mechanism (ERAM). The ERAM procedure adjusts utility revenue based on the difference between predicted and actual sales to ensure that unexpected changes in sales volumes do not effect earnings. It is used only in one state (California).

The ERAM procedure removes the disincentive of lost revenue from lost sales which exists for most demand-side programs in all but California. California sets rates based on a forecast of future sales, which happens now in only 8 states. While ERAM removes an important disincentive, it provides no positive incentive for either increased demand-side activity or for successful demand-side achievement.

RESPONSE FROM COMMISSIONER STEPHEN WIEL
ON BEHALF OF MARUC RE:
MARCH 14, 1989 GLOBAL WARMING HEARINGS
SENATE COMMITTEE ON ENERGY & NATURAL RESOURCES

2. Return on Demand-Side Investment. Traditionally, all states allow utility companies to earn a fair return on their investments in power plants and electric distribution systems. This is the primary way electric utilities earn a profit. In only 10 states are utility companies now earning a return on their investments in demand-side programs. Most state commissions provide for these costs to be reimbursed as operating expenses.

Allowing a return on demand-side investment provides parallel treatment for demand-side and supply-side programs. It rewards demand-side activity without looking at demand-side achievements. The reward is not large enough, in general, to overcome lost revenues from lost sales.

3. Bonus for Achieving Demand-Side Goals. Some state commissions have rewarded utilities for certain demand-side activities. For example, the state of Washington has for a decade allowed a 2% higher return on demand-side investments than on supply-side investments. Wisconsin Electric Power Company has been offered an extra one percent return on conservation investment for every 125 megawatts of demand for electricity it avoids.

RESPONSE FROM COMMISSIONER STEPHEN WIEL
ON BEHALF OF MARUC RE:
MARCH 14, 1989 GLOBAL WARMING HEARINGS
SENATE COMMITTEE ON ENERGY & NATURAL RESOURCES

Madison Gas and Electric has been offered up to \$285,000 as a performance bonus (or \$285,000 as a performance penalty) for successful (or unsuccessful) competition in the energy services industry.

Offering a bonus for demand-side activity or achievement, whether it be a specified rate of return (on conservation investment, total equity or overall debt), or a specified dollar amount, can provide a positive incentive large enough to overcome the lost-sales disincentive. It can be used in conjunction with either or both of the first two mechanisms.

4. Shared Savings from Demand-Side Programs. Allowing utilities to keep a portion of the customer or societal savings from demand-side programs, like the bonus mechanism above, could provide a positive incentive large enough to overcome the lost-sales disincentive. It, too, could be offered as specific dollars or as an increase in rate of return. For example, Wisconsin Power & Light has been recently offered a return on equity increase which in magnitude is one tenth of the customer percentage savings from the demand-side program.

RESPONSE FROM COMMISSIONER STEPHEN WIEL
ON BEHALF OF MARUC RE:
MARCH 14, 1989 GLOBAL WARMING HEARINGS
SENATE COMMITTEE ON ENERGY & NATURAL RESOURCES

Likewise, Wisconsin Public Service has been offered a bonus (up to \$190,000) which is proportional to the kilowatt hours saved from its demand-side programs.

The shared savings mechanism has the advantage that the incentive offered to the utility company is directly linked to our societal goals. It rewards the utility directly for its success, not for its level of activity in demand-side programs. It requires more detailed regulatory analysis of demand-side programs than other mechanism and requires more careful monitoring of the results.

5. Bonus for Controlling Total Bill. The focus of this mechanism is on one of the regulator's true bottom lines: the customer's bills. The more efficiently the customer uses electricity, the lower will be his/her total bill. One version of this mechanism currently under public discussion in Maine would have the utility's allowed profit adjusted based on the company's average annual utility bill compared to those of a set of comparable utility companies. The utility's return on equity would be proportional within limits to the ratio of the increase in average bill for the comparable utilities to

RESPONSE FROM COMMISSIONER STEPHEN WIEL
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the increase in average bill for the utility being judged. The smaller the increase in the subject utility's average bill, the higher would be its allowable profit.

Providing a bonus (or penalty) based on control of the average customer bill could not only overcome the lost-sales disincentive but would also provide incentive for other non-demand-side improvements in company operation. If the subject utility is to be compared to other utilities as is being considered in Maine, there is the difficulty of choosing a set of comparable utilities acceptable to both utility executives and regulators. Furthermore, this mechanism is likely to evolve into a system of competition among all utilities.

We regulators must be careful in choosing and implementing changes to electric utility ratemaking formulas. Proper balance must be found to 1) offer large enough incentives to achieve efficiency, 2) still encourage productive new uses of electricity, 3) avoid undue regulatory discretion, 4) avoid undue administrative burden, and 5) ensure public acceptance. That balance is likely to vary from state to state.

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Twenty-three of the 206 total state commissioners in the U.S. who regulate electric rates (those on NARUC's Conservation Committee) are currently working to varying degrees in their own states and within NARUC to promote ratemaking reform of the type described above. The federal encouragement provided by S.324 would greatly accelerate the pace of that reform.

Question 2: In the provisions on qualifying conservation entities, you object to the option of paying the difference between avoided cost and average price for qualifying conservation. Why are you not bothered by the double payment problem inherent in paying full avoided cost?

Answer 2: To clarify the record, let me state the following. I do not object to state regulators having the option of ordering their utilities to offer any amount for qualifying conservation, although virtually all state commissions that have addressed the issue have rejected limiting incentives for conservation to the difference between avoided cost and average price. Furthermore, I agree it is important to avoid double payments. I do not believe that utilities should have the stated or any other option. And I

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do not believe that the Federal government should address this matter in legislation.

The question implies that the best or perhaps only way to avoid double payments is by limiting the price for qualifying conservation to the difference between avoided cost and average price. This is absolutely not true. In fact, it may be the worst. It not only would avoid double payments, it would avoid much of the societally beneficial conservation that is available throughout the United States today. We need to implement procedures which both avoid double payments and allow the implementation of all societally beneficial conservation.

Let's look at an example. Take a small utility company, one with two customers. Assume that before demand-side programs are implemented, each customer uses 1,000 kilowatt hours of electricity each month and is charged 10 cents per kilowatt hour of which 4 cents per kilowatt hour is fuel cost and 6 cents per kilowatt hour is fixed operational cost, overhead and profit. Each then pays a monthly bill of \$100.00 and the utility receives \$200.00 in revenue. Assume now that customer A has the opportunity to implement a lighting efficiency program which will allow her to achieve the same lighting level but her total monthly energy

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consumption will be only half (500 kilowatt hours) of what it was.

Immediately after the program is implemented, one customer would be paying \$50.00/month (500 kilowatt hours @ 10 cents per kilowatt hour) and the other would be paying \$100.00/month (1000 kilowatt hours @ 10 cents per kilowatt hour) and the utility would be receiving \$150.00 per month. But \$150.00/month wouldn't cover the cost of providing 1500 kilowatt hours. The company really needs \$180.00/month to deliver 1500 kilowatt hours (the \$150.00/month it was getting for the 1500 kilowatt hours it is still selling plus the \$30.00/month it was receiving to cover its fixed costs [6 cents per kilowatt hour times 500 kilowatt hours] from the 500 kwh it is no longer selling.)

The utility would then increase its rates to 12 cents per kilowatt hour in order to recover \$180/month. The customer who received the benefits of the lighting program would now be paying \$60.00/month, the customer who didn't would be paying \$120.00/month, and society would have saved \$20.00/month (which equals 4 cents per kilowatt hour saved) for less fuel used at the power plant, and would have saved the accompanying environmental costs.

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But let's assume that it costs customer A 1 cents per kilowatt hour to buy her new high efficiency lamps. Customer A is actually paying an extra \$5.00 per month (1 cents for each of the 500 kilowatt hours saved). Although the utility is saving \$20.00/month on behalf of all its customers, society as a whole after adjusting for customer A's cost is only saving \$15.00/month (3 cents for each of the 500 kilowatt hours saved).

The situation described above at the time Customer A was contemplating her lighting efficiency investment was as follows:

Average Price (per kilowatt hour)	10 cents
Short-term avoided fuel cost	4 cents
Utility savings	4 cents
Societal savings	3 cents
Difference between short-term avoided cost and average price	-6 cents

As can be seen, the difference between short-term avoided cost and average price is negative so no incentive would be offered even though there is 3 cents in societal benefits to be obtained. The - 6 cents has no relationship to either utility savings or societal savings.

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The situation is further complicated if customer A offers the utility a long-term contract which avoids a portion of a planned new power plant worth 1.5 per cents per kilowatt hour. Now there exists a long-term avoided cost of 5.5 cents per kilowatt hour (4 cents fuel component plus 1.5 cents capacity component). Likewise, the utility and societal savings each increase by the same 1.5 cents per kilowatt hour.

Now the situation is as follows:

Average price (per kilowatt hour)	10 cents
Long-term avoided cost	5.5 cents
Utility savings	5.5 cents
Societal savings	4.5 cents
Difference between long-term avoided cost and average price	-4.5 cents

Again, the difference between long-term avoided cost and average price is negative so no incentive would be offered. Again, there is no actual or conceptual relationship to either utility or societal savings.

In fact, suppose the efficient lighting were free to the customer but because of the market failures mentioned in my testimony, the customer was not installing it. The utility would

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still be precluded from offering the customer even 1 cent per kilowatt hour although the societal benefit would have risen to 5.5 cents per kilowatt hour.

The truth of the matter is that limiting payments to the difference between avoided cost and average price, often called the no losers test, is purely a test of equity and has no direct relationship to "double payments" (except that it is so overly restrictive that "double payments" as well as much worthwhile conservation would never occur.) Mandating the no losers test would preclude all conservation programs by utilities for which the cost of new power (avoided cost) is less than the current price (average cost), a common situation and one which exists in my own state, Nevada. For utilities with a high cost for new power, the no losers test would limit allowable payments severely below the available societal benefits.

While no losers test serves an important function in the evaluation of utilities demand-side programs, it should be used neither to eliminate individual programs nor in establishing rates to be paid by utilities for electricity, power, conservation, or load management.

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In the example above, the no losers would prevent this program from being implemented because rates would go up and one of the customers would have an increased utility bill. Despite the shift in costs between customers, the lighting program described is beneficial to society and should be encouraged, not discouraged. Consider the situation where there is another demand-side program which helps the second customer in the same way that this program helps the first customer. Then there would be another \$20.00/month savings to the utility (\$15.00/month to society), a \$30.00 savings to the second customer's bill and another \$20.00 increase to the first customer's bill. That would result in total payments to the utility of \$160.00 with each customer paying \$80.00. The no loser test applied to the programs individually would eliminate both programs before the equity in the combined programs was discovered.

In Nevada, we have our utilities calculate the rate impact using the no losers test. However, they are not allowed to eliminate programs individually because they fail the test. The utilities and the Commission simply use the results of this test to judge whether the societal benefits are worth any social inequities which result.

A "double payment" would always occur whenever a utility pays

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a customer an incentive. The customer than would receive his or her benefit in two forms--partly as a reduced bill and partly as an incentive payment. This only matters when the total of the two exceeds the societal benefit. The proper way to prevent an excessive "double payment" is to limit that payment to the societal savings.

Using the no losers test to avoid such non cost-effective demand-side programs is like using your hammer to kill a fly sitting on light bulb. There are ways to kill flies without breaking bulbs. Likewise, there is the societal test that will avoid overpayment but will not prevent lighting programs like the one described above.

One additional point is important. The original question implies that it is beneficial to pay some full specified cost for all qualifying conservation. We believe this also is not true. The allowable cost should be considered a cap on payments for power from qualifying facilities which now provide power under PURPA or for qualifying conservation without which the utility would actually end up spending the avoided cost. Utilities should be encouraged to purchase power or conservation below the allowable cost where possible. We believe it is the utility's responsibility

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to find the least cost future for its customers and society. We regulators should be helping our utilities to achieve this goal.

Question 3: Typically argument in favor of paying full avoided cost for qualifying conservation is that consumers currently demand a 2 to 3 year payback for conservation investment and thus that conservation investment requiring a longer recovery period won't be made without heavy incentives.

a) -- Won't the creation of a mandatory payment program for qualifying conservation create an energy services industry that will accept longer payback on investment?

b) -- Doesn't this fact obviate the need for full avoided cost payments?

c) -- Shouldn't we be somewhat cautious in our use of avoided cost payments, given the double payment problem and some of the excess payments that occurred in the early history of PURPA?

Answer 3: The argument in favor of paying up to full avoided cost for qualifying conservation is indeed as stated in the question.

Answer to subquestion (a):

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The creation of a mandatory payment program for qualifying conservation will help create a significant energy services industry, depending, of course, on the level, duration and certainty of payment. The utility industry will in effect be making attractive to the energy services industry the same untapped conservation opportunities that are now languishing in the homes, offices and industries of the utilities' customers. This energy services industry will surely accept longer recovery periods for its investments that the utility customers currently accept for theirs. Because it will not have the privileged status of a regulated natural monopoly and will therefore be inherently more risky, it is unlikely to accept payback on its investments as slowly as utility companies now do. Nevertheless, the creation of a mandatory payment program for qualifying conservation will dramatically close the gap that now exists between customers' returns on investment in demand-side measures and utilities' returns on investments in supply-side measures. The benefits to our society from such a program would be enormous.

Answer to subquestion (b):

The demand-side supply-side gap referred to above can be minimized by proper structuring of the mandatory payment program for qualifying conservation. It would be wrong to require

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utilities to pay full avoided cost for qualifying conservation just as it is wrong now to require utilities to pay full avoided cost to qualifying facilities. Nevada and many other states currently consider the utilities' established avoided cost as a cap on payments to facilities which qualify under PURPA. Through utility negotiations or formal bidding procedures, our utilities seek out the lower cost alternatives to reduce demand or increase supply. The Federal government should encourage states to use this approach. It should not require states to use specific formulas or to pay specific rates.

Answer to subquestion (c):

We indeed should be cautious in our use of avoided cost payments. It is true that we must avoid eliciting conservation which is not cost effective, and it is true that we must avoid excess payments such as those that occurred in the early history of PURPA. We have enough experience today that we can avoid such problems.

There is great diversity among us in the fifty states. There is diversity in the needs of our utility companies. Some have excess capacity and others are in immediate need. Some have high rates of customer growth. For others, the customer base is

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declining. Some have access to relatively inexpensive sources of power, others do not. And various diversity exists in political and regulatory procedures and administrative structure. The best procedure for finding and implementing least cost energy solutions in one state may or may not be appropriate in another state. One size does not fit all. A national program to identify and stimulate the achievement of a least cost energy future for the United States must account for such diversity.

I believe that all of the states are aware and sensitive to the issues surrounding the determination of avoided cost. We are able to make informed policy decision appropriate for our jurisdictions. We will not overpay, we will be cautious in our use of avoided cost payments, and we will find what are the least cost solutions in our jurisdictions.

EEl RESPONSES TO QUESTIONS SUBMITTED BY THE
SENATE ENERGY COMMITTEE IN CONNECTION WITH THE
MARCH 14 HEARING ON GLOBAL CLIMATE CHANGE

Page 1 of 4 - Question 1: In your opinion, will these new technologies ever completely displace fossil fuels in electric generating plants?

Answer: While it is certainly possible that solar, thermal and other such technologies will become part of the nation's generating mix, it is unlikely that these new technologies will completely displace fossil fuel for electric generation in the near future. Their primary application would seem to be in the area of peak generation supply and not for base load electric generation. We can all hope that at some time in the future a technical breakthrough will occur which would allow economical integration of these sources into our base load capacity, but we do not see this occurring anytime soon.

Page 1 of 4 - Question 2: If so, how soon will the displacement occur?

Answer: As stated above, we do not believe these technologies will completely displace fossil fuels for base load electric generation at any time in the near future.

Page 1 of 4 - Question 3: Do you envision a phase-in period for the new technologies?

Answer: As mentioned in the response to question 1, we can foresee a gradual phase-in of these new technologies as they become economically feasible for peak load purposes. We do not foresee significant use of these new technologies for base load generation purposes at any time in the near future.

Page 1 of 4 - Question 4: In your opinion, is there an opportunity for fossil fuels and these various new technologies to operate side-by-side?

Answer: As indicated in our previous responses, renewable technologies tend to be used as peaking capacity and complement conventional base load generation. Certainly, these technologies can and do now operate side-by-side.

Page 2 of 4 - Question 1: Do you know if any analysis has been done on the national economic impact of displacing coal as an energy resource?

Answer: We are not aware of any analysis which would contemplate displacement of coal as a national energy resource. In our opinion, coal does now and must continue to play a significant role in the provision of adequate electric supplies for the U.S. Contemplation of a complete displacement of coal, in our judgement, is simply unrealistic.

Page 2 of 4 - Question 2: In your opinion, will these new technologies create jobs and contribute to the economy at the level that oil, natural gas and coal do currently?

Answer: While we have done no specific studies on this question, it is our opinion that in the absence of some cataclysmic upheaval in the oil, natural gas and coal industries, these new technologies would not create jobs at a level supported by those industries currently. We are aware that these new technologies are labor intensive, but in order for them to create jobs at a level commensurate with oil, natural gas, and coal, we believe that these technologies would have to displace these fossil fuels. In answer to previous questions, we have indicated that we do not foresee this occurring in the near future.

Page 3 of 4 - Question 1: In your opinion, does this bill call for "urgent and extreme action"?

Answer: Some provisions of the bill call for "urgent and extreme action."

Page 3 of 4 - Question 2: What specifically do you consider "urgent and extreme" about the bill?

Answer: This bill suggests the goal of a 20% reduction in CO2 emissions from the U.S. by the year 2000 and further reductions in energy use per unit of gross national product somewhere between 2% and 4% per year through the year 2005. The actions necessary to achieve either one or both of these goals in the timeframes contemplated certainly can be termed urgent and measures extreme. As my testimony points out, the energy reductions necessary to achieve these goals when translated from percentages to real quantity are staggering. We firmly believe that greater energy efficiencies can be achieved in the years ahead. In fact, we are counting on just such increases. The acceleration necessary to achieve these goals, however, is extreme. For example, the bill requires the Secretary of Energy and the Administrator of the Environmental Protection Agency to complete a "National Least-Cost Energy Plan" encompassing all known alternatives in just 18 months. The plan is then to be implemented immediately upon its presentation to Congress. We believe that this timeframe is simply unrealistic. The issues involved are

extremely complex and do not lend themselves readily to the "quick fix." My testimony points out, for example, that some 43 states are engaged in attempting to produce or implement some form of "least cost" planning system. Utility companies and regulators have struggled for some time to produce an acceptable definition of the term "least cost." To date, there is no agreement on such a definition, and yet, the Secretary and the Administrator are not only expected to resolve all of the questions relating to this term, but then to construct and implement a variety of measures based on that definition in 18 months. It is, in our judgement, an extreme measure that such an action should be taken without any specificity in the bill regarding what is meant by the term "least cost." Finally, by any standard of judgement, a reduction of 2% to 4% per year in energy use per unit of GNP not only qualifies as urgent, but extreme, given the amount of energy such small percentages represent.

Page 4 of 4 - Question 1: You suggest that the acquisition of demand side and supply side resources should be separate. If double payment problems that attend conservation purchases are removed, is there any reason that the acquisition of demand and supply side resources cannot be integrated?

Answer: The current system employed by utilities in assessing the need for new supply side resources accomplishes this integration. The double payment problem occurs only when conservation purchases are treated as supply side resources rather than as a deduction from load forecasts. It must be recognized that certain conservation and load management activities will be undertaken by utility customers on their own without any inducement from utility companies. In addition, the utilities take into account conservation and load management program impacts in the construction of their load forecast. The load forecast then forms the basis of resource planning. In this fashion, both demand and supply side resources are integrated in a total plan designed to meet customers' energy needs on the most cost effective basis encompassing a mix of both demand side (as a deduction from forecast) and supply side (additions to resource) measures.

Page 4 of 4 - Question 2: You mention concern with the possibility that qualifying facilities under PURPA could be treated as qualifying conservation entities. Given that qualifying facilities are supply side resources which are only paid for power produced, why is there a potential conflict?

Answer: The potential conflict exists when demand side resources are considered part of supply side options rather than as a deduction from a load forecast. Under this treatment, a qualifying facility wishing to enter a utility system could do so under the guise of removing load from the system via hardware generation as opposed to conservation and load management activities. The bill's absence of specificity in this regard and its insistence that conservation and load management be considered supply side options, lead us to the conclusion of potential conflict.

Page 4 of 4 - Question 3: We have seen that most consumers demand a 2-3 year payback for conservation investment, but that conservation investment requiring longer payback may be cost effective. How would you deal with this problem?

Answer: Just as we do now. Utility companies provide a wide variety of incentives for conservation investments ranging from direct cash rebates to the low market rate financing proposals to shared savings arrangements to special rate designs to design and construction assistance. These and other measures undertaken by utilities have produced substantial reductions in the need for new capacity. As my testimony points out, since 1977 the need for some 21,000 megawatts of new capacity has been eliminated. Further, our estimates indicate that by the year 2000 this figure will exceed 45,000 megawatts of new capacity.

The fact that the market place sends strong signals regarding what they consider to be cost effective conservation and load management should not go unnoticed. Past attempts to redefine artificially the measures of cost effectiveness through Federal intrusion in the market place have not met with success. A prime example might be found in the solar energy tax credit program which, unfortunately, produced thousands of solar installations which, frankly, contributed nothing to the nation's energy supplies. Market place response and resistance is real and not easily overcome. Certainly, it is unreasonable to assume that a national least cost energy plan constructed over the short time span of 18 months would resolve this problem. Things can be and are being done to reduce payback times on conservation and load management investments that are cost effective. Measures taken which would make an investment which is currently not perceived as cost effective by consumers an attractive investment would obviously require substantial further capital inducements. The provision of these inducements, in turn, may raise the total cost beyond the point where the measure is cost effective in reducing energy demands. In short, some conservation and load

management measures may require an investment by someone other than the consumer of an amount more than the savings can justify.

Page 4 of 4 - Question 4: Does EEI believe it is a good idea for state ratemaking practices to allow a utility to maximize its profits to the extent that it chooses least cost alternatives?

Answer: We would stress once again the need for a clear definition of what is meant by the term "least cost." Utilities today have strong economic disincentives to construct new generating facilities. We have every economic incentive to manage system loads so as to minimize the need for new capacity. This minimization encompasses strong emphasis on conservation and load management activities, but it must be recognized that the need for cannot be delayed indefinitely. At some point new facilities must be built. Any regulatory scheme which would penalize a utility for having reached the point where new construction is necessary despite its best conservation and load management efforts should be opposed. Certainly, a prescriptive Federal standard applied nationwide would be inappropriate. We believe that such matters should be left to the discretion of state regulatory commissions charged with the responsibility of assuring both an adequate and reasonably priced supply of electricity and a fair return to utility investors. In a very real sense, utilities are already pursuing least cost strategies which rely on a mix of supply and demand side measures. In the absence of any definition of the term "least cost" as contemplated by the bill, it would be imprudent to change state ratemaking practices affecting the profitability or cost to the customer. We certainly have no objection to remaining profitable, but the bill gives us no clear foundation on which to evaluate a change in regulatory procedure. In any case, we believe that state regulatory commissions provide the appropriate forum for analysis and decision regarding what might constitute a least cost alternative.

FINANCIAL SUPPORT 1988

SOURCES OF FINANCIAL SUPPORT (Unaudited)

The Alliance relies on two types of funding: grants or contracts for specific projects and contributions that provide general support. Our supporters include philanthropic foundations, government, utilities, business and industry, labor unions and consumers. Our research, pilot projects, public education, and policy advocacy programs are made possible by these supporters whose generosity we gratefully acknowledge.

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 1987 - \$788,933

* Amounts shown are total amounts authorized.
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** Funds designated for 1989 Affordable
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APPENDIX II

Additional Material Submitted for the Record



AMERICAN ASSOCIATION OF NURSEYMEN

1250 I STREET, N.W. / SUITE 500 / WASHINGTON, D.C. 20006 / 202/789-2900

Testimony
before the
Committee on
Energy and Natural Resources
United States Senate
March 14, 1989

The American Association of Nurserymen (AAN) welcomes this opportunity to present the views of the nursery and landscape industry with respect to global warming and, specifically S.324 -- the "National Energy Policy Act of 1989." The views presented herein are also endorsed by the Wholesale Nursery Growers of America, National Landscape Association, and the Garden Centers of America.

AAN is the national trade association of the nursery, landscape and garden center industry. Founded in 1875, we represent approximately 4,000 firms across the country engaged in all segments of the environmental horticulture industry -- nursery farming, landscape contracting and garden center retailing. By almost any standard, our members are primarily small family-owned farms and businesses. The retail value of nursery crops sold in the United States in 1987 was estimated to be \$6.35 billion.

Mr. Chairman, obviously there is growing concern about the ecological stability of our global environment. Recurring

droughts, tropical deforestation, expanding desert regions and acid rain appear either to be changing the earth's climate or represent changes which have already occurred. [The prospect of global warming holds dramatic public policy implications with respect to environmental and energy policies. Unfortunately, conflicting theories based upon a general lack of scientific data, and understanding thereof, pose formidable obstacles to the effective implementation of public policies which may reduce the risks associated with climatic changes such as global warming.

As proposed, S.324 represents the nucleus for an aggressive energy and environmental strategy which this nation must implement to address the prospects of global warming. The legislation provides a national blueprint for energy conservation and research to improve scientific understanding and prediction of the effects of global climatic change. Senator Wirth is to be commended for his leadership in focusing attention to global warming and developing an obviously well-drafted initiative in S.324.

AAN is pleased to endorse S.324 as it represents an essential first step toward consideration and implementation of effective energy and environmental policies to address global warming. We must begin to understand the true scope of any global climatic problems so that national resources can be wisely committed to

mitigate its effects upon energy consumption, the environment, agricultural production, industrial development and overall standards of living. Certainly, the prospect of global warming demands nothing less than the close coordination of federal and private research efforts. The outline of federal responsibilities and research priorities, as provided in S.324, goes a long way towards this realistic goal.

Five of the warmest and driest years on record in the United States have all occurred during the 1980's. Droughts threaten agricultural production and tax our precious water resources. Tropical forests are being deforested at an estimated annual rate up to 27 million acres. Air pollution is contributing to acid rain and thereby damaging forest ecosystems. Carbon dioxide is reported to be increasing at the rate of one-half of one percent each year.

Planting trees and shrubs can help reduce fossil fuel consumption which is believed to be the major factor in carbon dioxide buildup contributing to global climatic changes. By providing a cooling canopy, strategically planted trees and shrubs can simultaneously reduce energy demands and cooling costs. By shading homes, offices, businesses and industrial buildings, trees and plants can make cities cooler and, certainly, more livable, aesthetically pleasing and environmentally sound. Foliage plants inside our homes,

businesses and offices can sponsor similar environmental change, as well as carbon dioxide exchange...only indoors.

While tree and shrub plantings will not cure the whole problem of global warming or climatic change, they represent a cost-effective approach which can be undertaken immediately -- while federal research programs are on-going. AAN has pledged support to the "Global ReLeaf" program launched by the American Forestry Association to plant 100 million trees in our cities and towns by 1992 to meet the growing challenges of global warming. It has been reported that this nation's carbon dioxide emissions can be reduced annually by 18 million tons just by filling the 100 million planting sites around homes and in cities and towns. Moreover, such efforts will reportedly save consumers an estimated \$4 billion in annual energy costs.

AAN is very pleased that Section 1103 of S.324 recognizes that targeted urban tree plantings can reduce significantly the air-conditioning needs of buildings. AAN strongly endorses S.324's call for a study to determine the cost effectiveness of such a tree-planting program and to outline public policies and incentives which will encourage public and private efforts to undertake such plantings.

- 5 -

To this end, AAN strongly urges this Committee to examine and incorporate into Section 1103 the more detailed approach adopted by H.R.1078 which was introduced on February 22, 1989 by Representative Claudine Schneider and cosponsored by 76 of her colleagues. Title VIII, Sections 801, 831 and 832 of H.R.1078 establishes urban forestry education and accelerated tree planting programs for conserving energy, reducing carbon dioxide emissions, improving urban air quality, and securing additional environmental benefits. The legislation also authorizes pilot projects to demonstrate the efficiency of tree plantings in ameliorating the warming effects of urban heat islands. These pilot projects are proposed to be cost-shared with the federal government matching not more than 50 percent.

These directives in H.R.1078 represent a solid first step towards the articulation of new policy goals needed to foster ecological stability in our global climate. AAN urges this Committee to amend the section on urban forestry in S.324 by incorporating therein the provisions of Title VIII, Sections 831 and 832 of H.R.1078.

Mr. Chairman, the prospect of global warming demands the immediate and determined attention of this nation. S.324 is well-drafted and will begin to foster the coordination of needed federal efforts. With the crucial additions noted herein,

S.324 will pose a formidable tool with which this nation can begin to commit necessary public and private resources.

Tree and shrub plantings represent a very low-cost means of significantly reducing energy consumption and carbon dioxide buildup. Tree and shrub plantings represent a step which this nation can take immediately to begin to mitigate the risks associated with the prospect of global warming. Trees and shrubs have a positive role to play and hold immediate benefits as this nation begins to tackle these pressing environmental issues.

The nursery and landscape industry stands ready to continue improving and beautifying the environment in which we Americans are fortunate to live. The American Association of Nurserymen applauds the introduction of S.324 and urges your consideration of the important points raised herein.

Thank you, Mr. Chairman.



American Council for an Energy-Efficient Economy

1001 CONNECTICUT AVE., N.W. SUITE 535 WASHINGTON, DC 20036 (202) 429-8873

Energy Efficiency: Let's Get Back on Track

Howard S. Geller

After a decade of increasing national energy productivity, the overall energy efficiency of our nation has stalled. Energy use in the U.S. rose about 8 percent during the past two years, in tandem with GNP growth. In contrast, energy use remained nearly constant between 1973 and 1986, even though GNP grew 36 percent during this period.

The jump in energy use in 1987-88 is harming consumers, the economy, and the environment:

- o Consumers are paying about \$30 billion per year in higher energy bills;
- o U.S. oil imports increased by 22% over the past two years, mainly as a result of increased energy demand;
- o Carbon emissions from fossil fuel combustion have increased by over 100 million tons (over 7%) in just two years, thereby accelerating atmospheric warming due to the greenhouse effect;
- o Acid rain emissions and urban smog have worsened.

The recent jump in energy use is due to a combination of factors, including low energy prices, abnormal weather, a rebound by energy-intensive industries such as steel and aluminum producers, and slowing efficiency improvements in some areas. For example, the average fuel economy of new cars is no longer improving from year-to-year -- muscle cars are back in vogue and neither automakers nor consumers are paying much attention to MPG ratings.

Without new policies to encourage greater efficiency, energy use is likely to keep rising around one or two percent per year. This will further harm consumers' pocketbooks, the national economy, and the environment. However, rising energy use

is not preordained. President Bush and the Congress could set a goal of eliminating energy demand growth and returning to at least the rate of energy productivity improvement experienced during 1973-86. This goal is technically feasible, cost effective, and it doesn't require personal sacrifice or economic stagnation.

Achieving this goal requires a broad set of policies that will stimulate efficiency improvements in our buildings, vehicles, and factories. Most important would be to:

- o adopt tougher efficiency standards on vehicles, appliances, buildings, and lighting products;
- o provide utilities with financial incentives for pursuing conservation and reducing the cost of energy services;
- o step up research on energy-conserving technologies and practices;
- o help industry become more efficient through modernization and technological innovation;
- o tax oil products when world prices are low.

The last item is unpopular -- noone likes paying more for gasoline. But the real cost of burning oil is a lot more than \$15 per barrel when we consider expenditures on national security and damage to the environment. If we don't curb our oil appetite, we will soon be importing over half our oil, thereby helping OPEC to regain it's grip on the world market.

If President Bush and the Congress recommit the nation to greater energy efficiency, energy use in 2000 could fall by one-fifth or more relative to current forecasts. As a result, consumers would save hundreds of billions of dollars, industries would become more competitive, air pollution would be reduced, climate change slowed, and oil imports cut. In addition, by eliminating our energy waste, we set a positive example for other nations. Few actions by President Bush and the Congress could have such wide-ranging benefits.

American Wind Energy Association

TESTIMONY OF
THOMAS O. GRAY
EXECUTIVE DIRECTOR
AMERICAN WIND ENERGY ASSOCIATION

ON

S.324, THE NATIONAL ENERGY POLICY ACT OF 1989

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

March 14, 1989

Board of Directors

President

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Charles N. Davimport
Seawind Power Systems, Inc.

Robert Lynette
R. Lynette and
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Donald Marier
Alternative Sources
of Energy, Inc.

Robert H. Muller
Coughlin Brothers, Inc.

Robert W. Sherman, Jr.
Atlantic Coast Corp.

A. Norman Tenny
Green Mountain Power Corp.

Environmental Policy Advisor
Christopher Flavin
Worldwatch Institute

American Wind Energy Association

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Robert H. Monroe
Cruikshank Brothers, Inc.

Robert W. Shewchuk, Jr.
Kelpie-Orient Corp.

A. Norman Terrell
Green Mountain Power Corp.

Environmental Policy Advisor
Christopher Harsh
Worldwatch Institute

The American Wind Energy Association (AWEA) appreciates the opportunity to present testimony before this Honorable Committee. AWEA is a trade association which represents the manufacturers of wind electric turbines and components, and related companies. About 150 companies are members of AWEA.

AWEA strongly supports S. 324, the National Energy Policy Act of 1989, and urges its passage by the Senate and Congress. Wind energy has tremendous potential to help alleviate global warming by producing electric power without the carbon dioxide emissions of fossil fuels.

Wind Energy Is Working Today

Wind energy is similar to hydropower: a turbine, powered by the wind instead of water, produces electricity or mechanical energy. Wind electric turbines, 16,000 strong, are providing power today to electric utilities in the United States. This year, they will generate 1.8 billion kilowatt-hours (kWh) of electric power -- more than enough to meet all of the residential electricity needs of the city of Washington, DC.

Wind Energy Is Abundant

Even though only a fraction of the total wind blowing over the United States can be harnessed to provide electric power, wind energy's potential is still vast. Two studies for the Energy Research and Development Administration a decade ago concluded independently that wind electric turbines could supply up to 1 trillion kWh of electricity per year -- an amount which would be equal to about 40% of current national consumption.

Wind Energy Is Cost-Effective

While wind energy today, at 7-9 cents/kWh, still costs more than hydropower or coal-fired power, it is cheaper than power from many new nuclear plants and most other renewable energy sources, and its cost is dropping (see Figure 1). And there are no environmental cleanup costs to be paid in the future. A recent study, "Social Costs of Energy Consumption," for the European Community found that a wind turbine, over its lifetime, saves society more than its cost by reducing environmental damage and other costs of fossil and nuclear power.

1730 N. Lynn Street, Suite 610, Arlington, VA 22209 USA Tel. (703) 276-8334 Telex 6503304640 MCI UW

Wind Energy Is Clean

Wind turbines can help prevent or slow global warming by cutting fossil fuel emissions. A single wind turbine, if substituted for coal, will prevent the emission of nearly 18 tons of carbon dioxide per month (see Figure 2). AWEA estimates that 20,000 megawatts of wind electric capacity could be installed by the year 2000, producing some 41 billion kWh annually and reducing CO2 emissions by 51 million tons per year. And wind electric generation also avoids emission of sulfur dioxide, nitrogen oxides, and other gases linked to air pollution and acid rain.

Wind Energy Is Domestic and Renewable

Since wind energy is domestic, it creates local jobs, and its use will not add to America's trade deficit. And since it is renewable, obtaining power from the wind does not deplete our limited supplies of fossil fuels like oil and natural gas.

A Wind Energy Program

AWEA recommends a series of legislative and regulatory steps aimed at encouraging development of this clean and abundant energy resource. Some of the most important include:

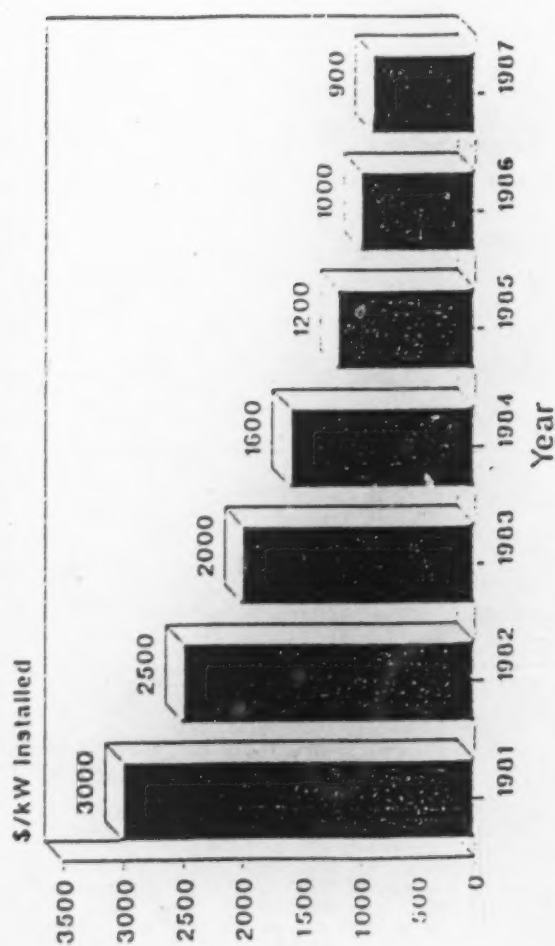
- 1) Production incentives for windfarm operators similar to any that may be proposed by the Bush Administration for oil. Such incentives would be tied directly to electricity production.
- 2) Increased federal research and development funds for a new, advanced wind turbine which would operate at lower speeds and generate power more cheaply, making it possible to develop windfarms in many areas of the United States. The federal wind energy R&D budget has been slashed by 90% since 1981.
- 3) A federal requirement that environmental costs of energy sources be considered in setting rates for the purchase of electric power or generating capacity.
- 4) Funding for wind resource assessments by the Department of Defense and other federal agencies for military bases and other federal properties.
- 5) Increased funding for renewable energy trade programs to encourage wind energy development overseas and assist the U.S. wind industry in competing in the international market.

AWEA commends the Committee and its distinguished members for investigating the problem of global warming and possible solutions. There are many problems facing the U.S. and the international community today, but certainly, this is one of the most challenging.

We would be pleased to provide further details on these proposals and others at the Committee's convenience. Again, we appreciate the opportunity to present testimony.

WIND ENERGY COSTS DROP

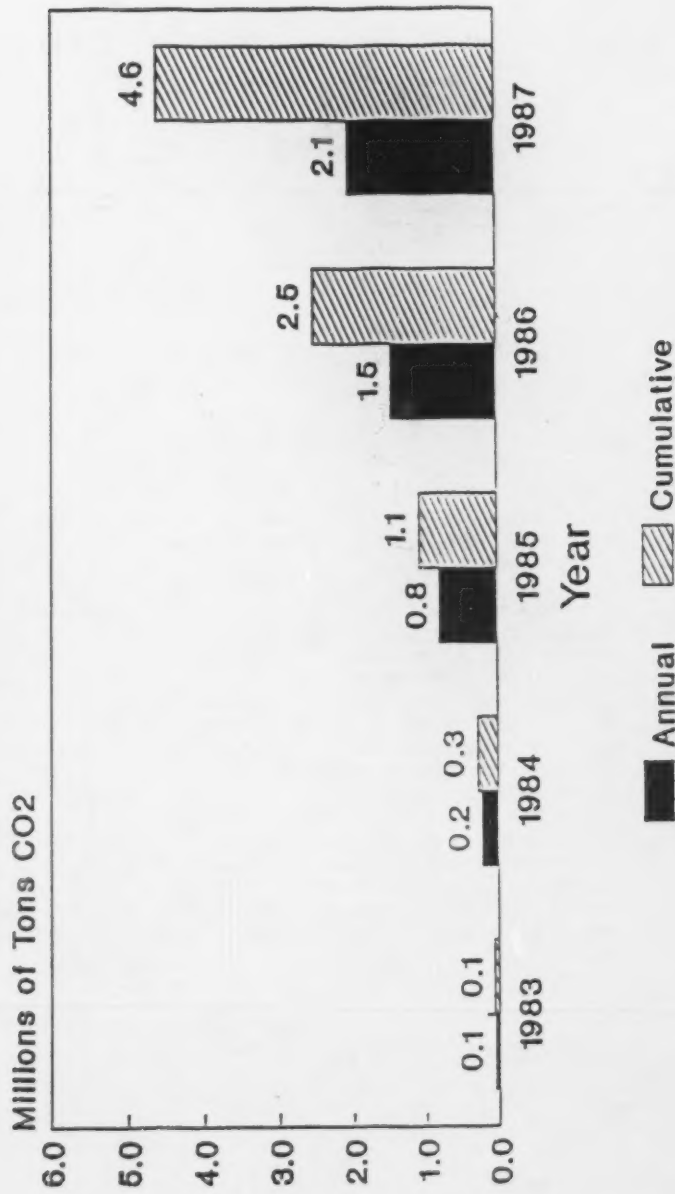
Cost/kW Installed, 1981-1987



AWEA/R. Lynette & Associates, 1988

WIND AND CARBON DIOXIDE

Wind's Impact, 1983-1987



Based on offset of coal-fired generation.

Amer. Wind Energy Assn., 1988



ENVIRONMENTAL AND ENERGY STUDY INSTITUTE

NOTICE

KEN MURPHY, EXECUTIVE DIRECTOR • 121 C STREET, N.W., SUITE 700, WASHINGTON, D.C. 20001 • (202) 638-1400

March 6, 1989

Solar energy: Its present and future

**Monday, March 20
3 p.m., H-137 Capitol**

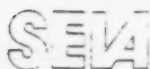
Can recent advances in solar technologies help slow global warming, cut oil imports and increase export earnings? The Environmental and Energy Study Institute invites members and staff to a briefing on this question, the current status of the U.S. solar industry and its future outlook.

Dr. Paul Maycock, director of Photovoltaic Energy Systems, Inc. and former head of photovoltaics research at the Department of Energy, will discuss the success of photovoltaics to date, future world market forecasts and the impact of photovoltaics on the environment. Photovoltaics are already playing an important role in some developing countries; in 1986, half the photovoltaics sold were used to provide power to equipment or villages not hooked up to electric utility power lines.

Dr. Bim Gupte, from the Solar Energy Research Institute, will discuss applications of solar collection technologies. These technologies concentrate heat to generate steam for industrial processes and electricity. Spinoffs of concentration techniques include using heat to break down hazardous wastes.

Scott Sklar, director of the Solar Energy Industries Association, will discuss DOE-funded research and development efforts and how the United States can prevent "the VCR syndrome" — the development of technologies such as VCRs in the United States that are subsequently manufactured exclusively in other countries.

This briefing is part of a series on energy issues present by EESI in cooperation with the Environmental and Energy Study Conference. For more information, contact Ann James at 628-1400.



SOLAR ENERGY INDUSTRIES ASSOCIATION Suite 610 1730 North Lynn Street Arlington, Virginia 22209-2009 (703) 524-6100
FAX: (703) 527-2833

FOR IMMEDIATE RELEASE

Contact: Scott Sklar
703-524-6100

SOLAR INDUSTRY LAMBASTS PROPOSED 1990 BUDGET

WASHINGTON, D.C., January 10, 1989 -- The Administration's FY'90 budget proposal, released yesterday, recommended a 30 percent cut in federal photovoltaics research and development, an 11 percent cut in solar thermal R&D, and a 22 percent cut in the solar buildings R&D budget.

Scott Sklar, Executive Director of the Solar Energy Industries Association (SEIA), called the recommendations unbalanced and irresponsible public policy. Sklar lambasted the Administration's budget pointing out that nuclear energy R&D programs (not including nuclear waste R&D), currently \$352.7 million in FY'89, was cut less than 1% to \$350.7 in FY'90. He also emphasized that both Germany's and Japan's federal solar R&D programs now surpass the United States solar research effort by over 30 percent.

Recommendations to cut the FY'89 \$35.5 million photovoltaics research budget to \$25.9 million, the \$15 million solar thermal budget to \$13 million, and the \$5.4 solar buildings R&D budget to \$4.2 million could threaten the U.S. predominance in solar technology and will essentially terminate the federal laboratory programs at the Solar Energy Research Institute and Sandia National Laboratories. Sklar described the proposed cuts as "tantamount to closing down the United States solar research effort, which he likens to 'VCR Syndrome' where the United States spent billions of dollars on research only to import the technology later on from our international competitors who commercialized the technology."

Sklar urged the U.S. Congress to redirect the budget to greater support of solar technologies to reduce the threat of global climate change due to the release of "greenhouse gasses" through the burning of fossil fuels and to reduce our dependency on imported fuels.

The Solar Energy Industries Association, the national trade organization of the photovoltaic and solar thermal manufacturers and component suppliers, reports that over 60 percent of photovoltaics sales in 1988 were exported, over 200 megawatts of solar thermal power has been interconnected to the utility grid, and more than one million homes in the United States have solar water heating. "The solar industry has received bipartisan support for solar energy development", according to Sklar, "and the industry urges the President, the Secretary of Energy and the Congress to maintain the international competitiveness of our industry that has a potential multibillion dollar overseas market."

By Jay Matthews
Business, Nov. 20, 1997

KRAMER JUNCTION, Calif.—Almost on the centennial in 1964 when a few American and Israeli engineers opened a small water-irrigation plant near the ramshackle community in the Mojave Desert. Their effort was written off as another stupor because cotton is said to be the group's next on order crop.

New, however, is the turbine built with 194 megawatts of power drawn from spreading costs as though the parabolic errors and the company began to depreciate \$1.2 billion expenses, major U.S. utility executives and World Bank economists are starting to feel the enterprise is an international challenge.

The Los International Ltd. company has learned, with almost no effort, the largest solar-power facility ever built and the source of an estimated 90 percent of the world's electricity drawn from the sun's radiation.

At a time when some countries are preferring economic and environmental constraints from the "greenhouse effect" caused in part by oil- and coal-fueled power plants, policymakers are thinking again about solar power and searching for information about Luf's rapid growth and technological innovation.

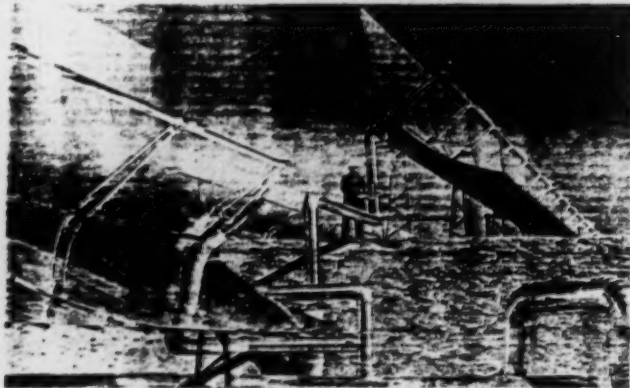
"We believe that they are far and away on the leading edge of the technology," said John McCauley, vice president of Pennac Capital Investment Corp., which owns a large share of the project as a subsidiary of Pennac Electric Power Co. in Washington.

"That is the world's most advanced effort to bring solar energy into large-scale production," said Scott Sklar, executive director of the Solar Energy Industries Association. He and other experts said the project shows that solar power can become a vital supplement to more traditional energy sources, particularly during peak daytime hours, at low cost.

"We are seeing our company get a jump on its expenses," said Chris Jones, a chemical engineer who

...and we'll already be there."

Increased in its early years by federal and state tax incentives, favorable regulatory rules, a lucrative local power contract and the construction of massive fossil fuel-



The information provided on this page is for informational purposes only and is not intended to be used for any other purpose.



Life is negotiating new contracts with the Iraqi Gas and Electric and exporting sales for plants in Armenia, New Mexico, Brazil and India. Company officials claimed that their power costs would be even cheaper if governments compared the costs not only of building a coal or nuclear plant but also of digging up fragile landscapes for more coal or uranium and polluting the air and water.

ness, one of its founders. Last year, it employs 700 people in California and Israel and recorded \$150 million in revenues last year.

Although the tax incentives are almost gone in an era of budget deficits and clamp net, a change in federal regulations has allowed the company to build five larger plants capable of tripling its generating capacity to almost 600 megawatts, enough for the residential needs of a city slightly larger than Washington.

Robert Lee Martin, deputy assistant secretary for minerals energy at the Department of Energy, said he was particularly impressed by Lee's skill in finding a large market for its product. "It's very clear that they have been a substantial

Company officials said investors and the new plants' larger size and several technical improvements should decrease the crucial cost of

ular power is about eight cents per kilowatt hour. That is less than the cost of power from new nuclear plants and closer to the average cost of electricity, about 10 cents per kilowatt hour, than solar-power engineers hope ever achieved.

Article and the Solar Energy Industries Association, based in Arlington, Va., are calling for a reversal of direction. Government support of

research in development of both solar-thermal energy and other major solar technologies, particularly the direct sunlight-to-electricity conversion called photovoltaics, which can also power watches and calculators.

Both under thermal and photovoltaic, the association said in two reports last November, the two government maintain strengths: "The U.S. competitive edge, provide reliable domestic energy, lower environmental degradation, strengthen national security, lessen Third World debt and cut the U.S. balance of trade."

Lot was founded in 1979 by Goldman, an American engineer with a reputation as a demure visionary and clever businessman, and Patrick Frenson, a French S-

Goldman's reputation as the man who invented one of the first mass

processors and who sold his own-made Lustron Corp. to Raytheon helped me understand better the role of the military in the nuclear energy program.

The company began research and development in Israel, where Goldstein and Pinesman also have citizenship. In a telephone interview from Jerusalem, Goldstein noted that laser interferential technology is "quite old" but that research at places such as Texas Mineral Laboratory in New Mexico and his own experiments gave it "an efficiency that it had never attained before."

The Lax contains two long troughs of curved mirrors, guided by computers, to heat synthetic oil passing through vacuum-coated tubes to 735 degrees Fahrenheit. The oil is then blown away to produce stumps and run an electric turbine.

They cut up the first small, 14-cup-sized plant in Dagupan. 20 miles east of here, added a carrot,

then built their third through several plants in this city and strip about 160 miles northwest of Los Angeles near Edwards Air Force Base. Kasser jetties compressed little more than a few gasoline stations and some roadside services such as "The Greasy Spoon," but in

Left the desert dry after the rain had passed around 7:45 Sunday with "blue sky," a temperature source of water release usually induced by wind, clouds or rain.

Southern California Edison Co., which buys low-generated power, is exempted by federal law to purchase electricity from qualified small suppliers. But the huge utility, impressed by Lee's performance, has given the solar company state and available 20-year power contracts.

On hot summer afternoons when demand from millions of Los Angeles air-conditioning units, the sun beating down on Kramer Junction gaspores constant solar power. "It's almost poetic, it's such a perfect match between solar and what

In the winter, when the sun's rays are weaker or when there's more snow cover, it's best to turn California's remote and deep.

can save a small natural-gas boiler to supplement or replace solar power. The plants qualify for exemption from expensive federal paperwork requirements if no more than 25 percent of their power each year comes from such nonrenewable sources as gas.

Workers who arrived at Kasser Junction when Billy asked that employees depict the landscape inside their heads at the new office building, the acres of turners and the vertiginous tangle of heat-traveler pipes spreading over the desert.

These studies suggest that the
the following: (1) The Police
or control the system of the
the

Several Los Angeles and overseas residents addressed a Thanksgiving audience at the convention of the World Council, a welcoming cup of sympathy to many workers here. They used to say, "You'll never do it," James said. "Now they say, 'Yes they do.' We're committed."

Solar Energy Firms Await An Economic Breakthrough

SOLAR FROM FI
Solar energy advocates warned that the real potential of solar power will be realized only when the United States may be abandoning its world leadership in the promising but frustrating field.

The conviction was expressed by the American Solar Energy Society, which became involved in solar power research in 1971. The society is now preparing to cut the amount of solar energy used in the United States by 80 percent by 1985. It is now planning to build a solar power plant in the United States, which would be the first of its kind in the world.

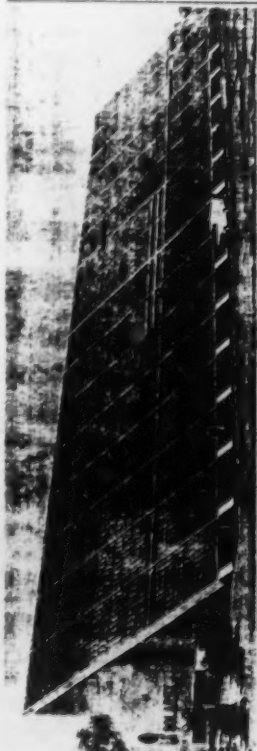
That such, however, is at the very least several years away. "My guess is that it will take 10 to 15 years to get the solar industry to a point where it is competitive with other methods of electricity production," says one solar energy expert.

For years, makers of photovoltaic cells have been working to reduce the cost of producing electricity from solar energy. The cost of solar cells has been dropping steadily, but it is still too high to be competitive with other methods of electricity production.

For many reasons applications where the electrical grid doesn't reach, we are now competitive with other power sources," says one solar energy expert. "We are now competitive with other power sources in many areas where the electrical grid doesn't reach."

There is one more reason why solar energy is not being used more widely. "The biggest problem is that solar energy is not yet a commercial product," says one solar energy expert. "We need more government support to get the solar industry to a point where it is competitive with other methods of electricity production."

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Nearly 35,000 square feet of roof-mounted solar cells power Belmont's Publicity plant. The Back-to-the-Sun firm is an Atlanta Corp. subsidiary.

Solar Industry Makes Gains—but Not on the Bottom Line

By Martin Chabrow
For the handful of U.S. companies that are making a name for themselves in the solar energy field, the bottom line is not as bright as the headlines suggest.

Like numerous other emerging high-technology industries, the solar energy business has found itself in a bit of a bind. While the industry has made significant gains in research and development, it has not yet been able to turn those gains into a profitable bottom line.

One of the main reasons for this is the high cost of solar energy. While the cost of solar cells has been dropping, it is still too high to be competitive with other methods of electricity production.

Another major problem is the lack of government support. While there has been some government funding for solar energy research, it has not been enough to get the industry to a point where it is competitive with other methods of electricity production.

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Arco Is Trying to Sell Solar-Panel Unit, Reversing Move Into Alternative Energy

By BARBARA ROSENTHAL
And FREDERICK ROSS

Staff Reporters of The Wall Street Journal

Atlantic Richfield Co. is trying to sell its solar-panel business, reversing its march into the alternative energy field and raising concern that foreign investors could cash in on an emerging U.S. technology.

Two foreign companies that have joint investments with Arco Solar—units of Japan's Showa Shell Sekiyu K.K. and of West Germany's Siemens AG—are believed to be looking at the company. In addition, the unit's former president, James Caldwell Jr., has taken a leave of absence to organize an attempt to buy Arco Solar.

A spokesman for Arco, an oil company based in Los Angeles, declined to discuss possible purchasers. He said the unit has been on the block since last year.

The prospect that a foreign company might buy Arco's solar-cell business furthers proponents of solar-energy development. Arco Solar is the leader in the fledgling \$160 million solar-cell industry, which uses photovoltaic cells to convert the sun's energy directly into electricity. The technology was invented in the U.S. and has been developed with the help of taxpayers' dollars. Although the Reagan administration sharply cut such spending in 1981, the U.S. government still has poured \$200 million into photovoltaic research and development since then.

"There's an energy for the future developed in the U.S. that could end up just like the VCR industry," said Ed Rutherford of the Citizen/Labor Energy Coalition, a consumer group in Washington, D.C.

"Just when we're about to the point to commercialize and reap the benefit, we give up," said Scott Sklar, a Washington lobbyist for the solar technology industry.

"That's what's tragic," President Bush's fiscal 1986 budget requests \$24 million for research, compared with \$34 million when the Carter administration left office.

Japan and West Germany are the U.S.'s biggest competitors in the world-wide solar-cell business, in which U.S. market share has slipped to 35% from 60% in 1981. For the first time last year, each country poured more money into the research than the U.S. government, Mr. Sklar said.

The technology, which still is too costly for large-scale energy generation, is used to power devices such as irrigation pumps, refrigerators and calculators. Mr. Sklar said 60% of sales are exports.

Arco built its operation from a tiny, eight-employee company acquired in 1977 into the world's largest producer of photovoltaic cells. With about 100 employees and annual sales over \$80 million, it makes a line of compact solar cells used to charge batteries at remote locations such as high-

way emergency telephones and beacons.

Arco Solar boosted its production capacity in recent years. But a company spokesman said Arco found the business disappointing, producing "variable" profits on operations but losses when research and technology were counted.

Analysts said the decision to sell Arco Solar reflects a continuing, hard-eyed view of operations by Arco's current management. "Since 1983, when they undertook a massive restructuring, Arco has been considering its businesses as a portfolio and has been winnowing them as a professional investor would," said Bernard Picchi, an analyst at Salomon Brothers Inc.

Arco is trying to sell its solar-panel business, reversing its move into alternative energy. The decision also raises concern that foreign investors could cash in on U.S. technology.

(Story on Page B2)

The New York Times

NEW YORK, THURSDAY, MARCH 7, 1980

U.S. Companies Losing Interest In Solar Energy

By MATTHEW L. WALD

Some of the nation's biggest backers of solar energy are losing interest just as the technology is getting closer to being economically competitive with some conventional power sources.

The world's largest maker of solar cells, ARCO Solar, is on the auction block because the parent company, which once saw its investment as a hedge against future shifts in the energy market, now believes it can put its money to better use where it has the most expertise, in oil and gas.

Photovoltaic cells, which make electricity directly from sunlight, are usually made of silicon, although manufacturers are experimenting with a variety of materials in different shapes: some are flat plates, and others are installed under lenses that magnify the sun's rays.

Too Slow to Compete

The cells are still about four times too expensive to compete with ordinary coal-powered plants, this country's main source of electricity, and still triple the cost of the most expensive electricity, the inefficient sources utilities turn to at hours of peak demand. But in the early years of this decade, the cells were 16 times too expensive, and the price is still falling.

If ARCO still the solar subsidiary it bought in 1977, it would follow the Exxon Corporation and the Shell Oil Company in leaving the business. Motorola Inc. has also left the field. But the Amoco Corporation is still a significant presence, through its Solaris Corporation subsidiary, which is the second-largest domestic manufacturer.

Experts say the waning interest of American companies may mean that if

the photovoltaic industry becomes a giant, it will be dominated by Japan, which already has a lead in production of low-technology solar cells. West Germany is also a competitor. Potential leaders for ARCO Solar include Apple and Texaco companies.

The prediction, made by the field, is to draw big corporations to the country to do not see a sure enough prospect of substantial returns on their investment to spend years on further development of solar power. They would rather put the money in their own businesses of oil and gas.

People in the industry believe that sometime in the next decade solar cells will provide cheaper electricity than generators that consume oil or gas, it could then become a mainstay of the dollar industry.

The problem is that so far, however, even when they will enter the market, they will be competing with a technology that is already in a position to do so, said James H. Caldwell, a 35-year veteran of ARCO who until last year, when he left to try to assemble investors to make a bid for it.

Some are troubled by the possible "leakage" of the technology of solar energy's progress to the rest of the world, which is considered to be a foreign country, said Kenneth E. Fiedler, vice president of the Federal Research Council on Solar Energy Conversion. "The Federal Government is not developing a market for solar energy technology, which is sold in the form of photovoltaic cells in the United States in the next three to five years," ARCO, he said, "has the global leadership in this technology."

A spokesman for the company, James H. Lewis, said, "ARCO's hope is that we'll find a buyer who will acquire ARCO's world-class development of this technology."

The world market for solar cells is now only about \$15 billion a year, but if the cost of solar cells continues to fall — as it will and natural gas rise to prices — the technology will have real economic importance. A few years, utility experts agree.

Samuelson on Short-Term Future, said "I don't see us really there," said Philip R. Vetter, Jr., an energy economist at Charles River Associates, Inc. He said that some had come down by 40 percent since the mid-1970s, but he developed for the energy program.

But American corporations are "too slow to start-up profit" to catch with the movement, he said, and a publicly held company that is not heavily in solar technology would probably become the target of a corporate raider, who would argue that "shareholder" money could get superior private companies.

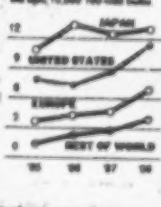
"It's the VCE syndrome," said Lewis Fiedler of the Solar Industries Association, a trade group in Washington. The technology to make value-added materials is being developed in the United States but is controlled by foreign manufacturers, especially the Japanese.

Government Catalysts Proposed

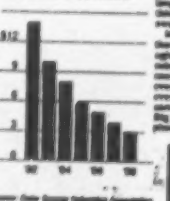
"The clear we get, we ought to have more coverage, more willingness to come in the market," said Representative Vito Marcini, a California Democrat who is a leading Congressional leader of solar power. "We are getting on legislative reaction."

Senator Edward Brooke said he was talking to the Bush Administration, which has proposed a 30 percent cut in research and development funds from

World shipments of solar cells, by megawatts. One megawatt cell type, 10,000 100-watt cells.



Cost of a solar cell per peak watt of electricity produced.



Source: Solar Energy Industries Association

the current \$25 million. The Federal Government would be spending over \$10 million but not returned cost proposed by President Ronald Reagan, in 1980 the Government spent \$10 million a year.

Last year, for the first time, the Government of West Germany and Japan spent more on research and development than Washington did, according to the Solar Energy Industries Association, a trade group.

Power that is to be high.

But the rate is coming at a time when experts say solar technology is in its first major push: production of solar technology is coming with the most expensive power sources used by electric utilities, the services provided by natural gas or light fuel oil. Utilities turn to these high-cost services on hot, sunny afternoons when all the cheaper sources of power, like coal and hydroelectricity, have already been tapped.

The ability to provide that electricity, called "peaking power," as a competitive cost could come to some attention in as little as two to three years, said Edgar Tuller, manager

The growing field may come to be dominated by the Japanese.

of the solar power program at the Electric Power Research Institute, a utility-sponsored research organization in Palo Alto, Calif., that sponsors the industry and sponsors some work of its own.

"The industry isn't really catching up," he said, "but I think it will, eventually."

In Washington, Robert H. Aron, director of photovoltaic research at the Energy Department, described the state of the industry in terms of cost per kilowatt-hour — the amount of electricity needed to light 100-watt bulbs for an hour.

"Right now, this technology is at about 30 cents a kilowatt-hour," he said. "I think it will be down to 10 cents a kilowatt-hour in 10 to 15 years," about the same cost as to get electricity from their least efficient plants when fuel prices are high.

If the cells are used for peaking power, storage is not a problem, said Tuller, and that could mean more

air conditioning demand, which is highest when the sun is brightest. Even at the current low level of solar conversion, American consumers increasingly see the solar cells entering the marketplace.

First even the day uses, like parking lots, but for several years, companies have been equipping their commercial vehicles with panels of cells to handle larger loads, like charging the batteries that run small refrigerators, television sets and fluorescent lights.

Now, recently, demand power has begun cutting garden ordinary lights that need no wiring, cells built into the roof of a factory during the day. Several hundred Ohio residents are equipped with solar cells that keep the battery charged when the sun is not shining, eliminating the drain from digital clocks and on-board computers.

Some Companies in Third World

Around the United States, solar cells are widely used to power communications relay stations, lighthouses and other remote sites. They are for more common use in the third world, however, where the cells power irrigation pumps and charge the batteries that run telephones and radios where there is no electricity, and power refrigerators for remote health clinics.

While many of these uses make the technology or they make markets, they provide no increasing demand. But officials of ARCO said that the market was not growing fast enough. The chairman, Fiedler of ARCO, said in an interview last month that after 12 years of operating the subsidiary, he was "finding problems with solar power and ready to sell the company," which is in Cambridge, Mass., and has 50 employees.

ARCO Solar's Progress

The only price could be in the range of \$10 million to \$20 million, people in the industry say. ARCO has invested \$25 million of its own money, said Albert Grossmann, a spokesman for the company. He added that this investment had cost the \$1 million the company had, reported from the Government, ARCO Solar will get an additional \$100,000 to Federal financing this year.

ARCO's exit, some industry experts believe, would provide a quick lesson for advancement by the Government or the Japanese. Two possible buyers, they say, are Siemens A.G. and Solaris Inc. Solaris, a subsidiary of Amoco, is still in the market. ARCO Solar is a subsidiary of ARCO Solar.

But Mr. Aron of the Energy Department said energy was not certain that through research would replace a certain level, Mr. Caldwell, the former president of ARCO Solar, said: "The United States has the largest concentration of technical talent, and the biggest market in the U.S. As long as there are firms, it's not impossible that somebody's going to meet away with you and take over."

Mr. Caldwell said he recognized that in some cases, "people are right" that ARCO wanted to sell the subsidiary. Regarding the days of the energy crisis, when all companies every move was studied for market overruns, he added, "They are the same people who were against the day of oil were the only people leading photovoltaics for a while."

Continued on Page D88, Column 4

ASSOCIATION OF HOME APPLIANCE MANUFACTURERS
20 NORTH WACKER DRIVE • CHICAGO, ILLINOIS 60606
312 984 5800
GOVERNMENT RELATIONS, 200 DAINGERFIELD ROAD
ALEXANDRIA, VIRGINIA 703/683-8822

March 13, 1989

The Honorable J. Bennett Johnston
Chairman
Committee on Energy & Natural Resources
United States Senate
SD-364 Dirksen Senate Office Building
Washington, D.C. 20510

Dear Senator Johnston:

The Association of Home Appliance Manufacturers (AHAM), which represents the majority of manufacturers of refrigerators, refrigerator-freezers and freezers sold in the United States, has an interest in your Committee's March 14, 1989 hearing on legislation (S. 324) to establish a national energy policy to reduce global warming.

The manufacturers of household refrigerators and freezers are facing a Catch-22 situation.

The very substances they rely upon to produce highly energy efficient refrigerators and freezers -- chlorofluorocarbons (CFC-11 and -12) -- are being phased out through international agreement because CFCs are harmful to the earth's stratospheric ozone layer. At the same time, the Department of Energy (DOE) is proposing potentially drastic increases in energy efficiency standards for these basic home appliances.

To illustrate the relationship of efficiency increases to use of CFCs, please note that this industry increased its use of CFC-11 by 55% to achieve the 96% efficiency increase for refrigerators achieved since 1972 and the 77% increase for freezers.

This industry has relied for almost 50 years on CFC-12 as the basic refrigerant gas and more recently on CFC-11 as a blowing agent for foam insulation. Now, it is feared that both of these CFCs are not only harmful to the stratospheric ozone layer, but they also contribute to the greenhouse effect. Appliance manufacturers and CFC producers are committed to phasing out use of these chemicals as soon as is practicable.

However, the reality is that there are no known commercially available substitutes for CFC-11 and -12 with comparable energy efficiency capabilities which do not also potentially contribute to the greenhouse effect.

The Federal law (National Appliance Energy Conservation Act of 1987) already mandates very strict energy efficiency standards for 1990. This industry can meet those standards. What it cannot do is commit right now to meeting higher standards until it knows what the new CFC substitutes will be and what their impact on energy efficiency will be. Once it knows this, it will need time to redesign and retool to mass produce those products. (Keep in mind that we produced nearly 8.6 million refrigerators and freezers this past year.)

In short, the household refrigerator and freezer industry does not know today what it can use to meet new standards tomorrow.

Some people are urging DOE to impose very strict new energy efficiency standards on the industry for 1993, in part to avoid building more electrical generating capacity which may contribute to the greenhouse effect, and, if later the industry finds it cannot meet those standards, then Congress can provide legislative relief.

We do not think this would be fair, sensible or necessary, especially since DOE cannot reverse standards once promulgated.

This industry is actively exploring joint technology development efforts with the Environmental Protection Agency (EPA) and DOE to find the right CFC substitutes and accompanying technologies as soon as possible.

We have every reason to hope, and expect, that higher efficiency levels can be considered and adopted before the end of this century. Should substitutes be found sooner, rather than later, we would expect both the industry and the DOE to come together to review energy efficiency standards.

Lest you think this industry is too cautious, please realize that we are talking about major and revolutionary changes to a product that is found in every U.S. household, a product that Americans consider a daily necessity and have come to expect will safely and reliably store their perishable food for at least 15 years or more. Furthermore, these are products that represent over \$3 billion in manufacturer sales -- over 28% of the home appliance industry's total annual sales.

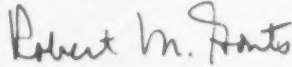
Clearly, time is needed to do the research necessary to find substitutes for CFCs which do not contribute to the destruction of the earth's stratospheric ozone layer, and which do not exacerbate the greenhouse effect.

-3-

I respectfully request that this letter be made a part of the record of the Committee on Energy and Natural Resources' March 14 hearing on S. 324.

Thank you for giving the refrigerator/freezer industry the opportunity to advise the Senate on the challenges it faces in finding appropriate CFC substitutes.

Sincerely yours,

A handwritten signature in dark ink, appearing to read "Robert M. Gants". The signature is written in a cursive style with a large, stylized "R" and "G".

Robert M. Gants
Vice President
Government Relations

RMG:bdr

MANUFACTURING ≡ CREATES ≡ AMERICA'S STRENGTH

STATEMENT
OF THE
NATIONAL ASSOCIATION OF MANUFACTURERS

SUBMITTED TO THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE
ON
GLOBAL CLIMATE CHANGE

APRIL 4, 1989



National Association of Manufacturers
1331 Pennsylvania Avenue, NW, Suite 1500 — North Lobby
Washington, DC 20004-1703 (202) 637-3000

The National Association of Manufacturers is a voluntary business association of more than 13,500 member companies and subsidiaries, large and small, located in every state. Members range in size from the very large to the more than 9,000 smaller manufacturing firms, each with fewer than 500 employees. NAM member companies employ 85 percent of all workers in manufacturing and produce more than 80 percent of the nation's manufactured goods. NAM is affiliated with an additional 158,000 businesses through its Associations Council and the National Industrial Council.

EXECUTIVE SUMMARY

The National Association of Manufacturers is testifying as a lobbying association representing all sectors of the manufacturing community. The NAM believes the views expressed in this statement are consistent with the views of broad business groups as well.

The NAM and other business coalition members recognize that the Global Climate issues are unique and require additional study to understand the issues, their causes, effects and options to address potential climate changes, and the impacts of their possible solutions.

The NAM advocates three central elements regarding this issue:

- 1) The question of 'enhanced' Global Climate change is a potentially serious development and the NAM is taking it seriously.
- 2) Good science must be the foundation for policy actions and should be our first priority for action.
- 3) 'Exaggerated' Global Climate Change would be a massive development requiring global cooperation in its study and possible response strategies. Unilateral actions by the U.S. no matter how well intentioned, would not be sufficient and could be harmful to achieving solutions, if they are implemented without consideration for their social and economic impacts.

Unilateral actions taken by the United States could be counterproductive because of the need to link policy action worldwide. Given the uncertainties that exist in our understanding of global climate change, we should be cautious in our approach to taking steps that would be costly in societal and economic terms. Unilateral actions may prove ineffective as a response to the issue. Our policy should be to preserve the maximum degree of flexibility, and what we do domestically should complement the efforts of the international community.

NAM believes the efficient use of energy, should be a cornerstone of a national energy policy. The industrial sector has been the leading force for energy conservation in the United States. The management of energy for industrial use remains a strategic concern with implications for productivity, U.S. competitiveness overseas and the capability of meeting domestic energy needs.

A free energy market is our best guarantee of a secure energy future. However, NAM believes the federal government has a role to play in conservation, such as education, technology transfer, limited and voluntary data collection, and financial support for long-term, high-risk research and development where private sector incentives are inadequate.

NAM believes that the most efficient way to encourage industrial energy conservation investment is to promote a good overall investment climate in the economy. Industry, in response to market forces and investment climate, will make the most cost-effective and appropriate conservation investments. Energy conservation investments have been made and will continue to be made when they are economically feasible.

The National Association of Manufacturers (NAM) is pleased to submit this statement to the Committee on Energy and Natural Resources of the United States Senate on the issue of global climate change and the role of energy efficiency in national energy policy. This statement reflects the views not only of NAM but of a broader coalition of industry associations and individual companies that are concurrently coordinating activities on this issue closely with NAM. Both the NAM and the other business coalition members recognize that potential global climate change is somewhat unique and requires additional research and study to understand the phenomena, their causes and effects, options to address potential climate changes, and the impacts associated with each option.

NAM commends the Committee for conducting hearings to examine the role that energy policies have played and yet may play, both in contributing to potential climate change, and in presenting options to mitigate changes brought about by current energy consumption patterns. NAM wishes to provide specific views on energy conservation and energy productivity, but will first provide its overall views on the global climate issue.

There are three central elements to our position. The first is that the NAM and other business organizations believe that disproportionately large global climate change is potentially a serious issue

that could impact both our domestic economic base and the economic and environmental conditions of the world.

The second element is that we believe good science must be the foundation for policy actions. Achieving international consensus on what we know, and what we don't know about disproportionately large global climate change, is essential. In order to do so we must identify what new research is needed to better define the problem, to prove or disprove the theories, and analyze the impacts. This should be our first priority.

The third element is that enhanced global climate change is a global phenomenon, requiring global cooperation in its study and possible response strategies. Unilateral actions by the U. S., no matter how well intentioned, will not be sufficient and could be harmful to achieving solutions, if they are implemented without consideration for their social and economic impacts. Just as we continue to be concerned with the ability of our planet to adapt to climate change, we must also be concerned with shocks to our domestic and global economies. Precipitous changes in energy supply and use, for example, could cause economic and cultural jolts to all nations.

Recently the NAM Board of Directors approved a global climate policy which embodies these elements. The policy states:

Society is concerned that gases released naturally and by man's activities might change the climate on a global scale. NAM

supports the continuing development of climatic science to address the broad far-reaching questions on global climate changes. Any solution must be implemented multinationally. These solutions should weigh the magnitude of the contribution to the overall climatic alteration against the socio-economic impact of controlling these factors. We urge that international action on global climate change proceed and focus immediately on the causes, effects, and the impacts of possible solutions.

NAM supports aggressive research into the cause and effect of global climate change, the socio-economic impact of global climate changes and the impacts of proposed control measures. NAM also supports accurate and balanced public education to increase understanding on what is, and is not, known about global climate change.

Clearly, understanding global climate phenomena is a tremendous challenge for scientists, governments, public policy makers, and businesses to make certain that global economic development is sustainable and is compatible with the environment.

The United Nations and other international organizations are addressing both the many scientific uncertainties associated with the "Global Warming" hypothesis and the possible responses. The recently formed Intergovernmental Panel on Climate Change (IPCC) of the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) is perhaps the leading international body investigating this

issue. Business applauds this effort and fully supports the U.S. delegation's leadership role. NAM is also participating in the effort. In January, NAM President Alexander B. Trowbridge represented international business in testifying before the Response Strategies Working Group of the IPCC. NAM hopes the IPCC effort will culminate in development of a rigorous scientific foundation upon which to base sound multilateral policy objectives.

Unilateral actions taken by the United States could be counterproductive because of the need to link policy actions worldwide. We must also admit that scientific evidence regarding enhanced global warming is inconclusive. Therefore, given the uncertainties that exist in our understanding of global climate change, particularly in our ability to accurately predict the magnitude and rate of change, we should be cautious in our approach to taking steps that would be costly in societal and economic terms. Unilateral actions may prove ineffective as a response to the issue. We need to avoid a crisis management approach. Our policy should be to strive to preserve the maximum degree of flexibility, and what we do domestically should complement the efforts of the international community.

We do not argue with the notion that climatic change has occurred over the course of history and that it will continue. Some changes appear to have occurred due to long-term geophysical factors, while other shorter-term climate changes result because of natural events such as volcanic eruptions and other disturbances, like El Nino. Little can actually be done to prevent these events.

That the "Greenhouse Effect" is real is also not an issue. Without the Greenhouse Effect, the surface temperature of the earth would be about 60 degrees Fahrenheit cooler than today. There is also widespread scientific agreement that those gases in our atmosphere which contribute to the effect (primarily CO₂, CH₄, NO₂, CFCs, and ozone) have been increasing in concentration since preindustrial times. Further some scientists say there may be a linkage between this increase and speculation that the earth's average temperature is increasing.

Finally, there is evidence that greenhouse gas emissions, notably from man's activities, are likely to increase and this raises concerns about potential severe shocks to climatic equilibrium with resulting ecological, societal and economic damage. What the nations of the world are concerned with, therefore, is the relationship between climate and man-induced changes in composition of the earth's atmosphere. There are many complex processes underway at the earth's surface and in our atmosphere that we believe prevent us from drawing a simple connection between variations in the earth's temperature and man-made changes in the emissions of greenhouse gases. For example, the balance between incoming and outgoing radiation is also impacted by concentration of atmospheric dust particles and by volume and concentration of cloud and ice cover and vegetation. Moreover, scientists do not understand sufficiently the interactions between the carbon cycle, feedback mechanisms such as cloud formation and the role of the oceans as a heat and CO₂ sink.

Scientific journals, local and national press, and the media are regularly reporting on the global climate phenomenon. It seems new research and often new prophecies add to either new information or heighten public concern. However, even a casual review of the literature reveals the inconsistencies and uncertainties surrounding this issue--whether it be the inability of super computers to provide accurate climatic projections on a regional scale, the uncertainties behind the conclusions of official agencies' reports, or new information that can refute earlier conclusions, which at first appeared justified.

It is essential that if we must ask society to make changes in energy uses and lifestyles, we will have to sustain policies across national boundaries and through changes in the policies of governments.

This can only be accomplished if it is preceded by sound science that links theory to fact and clearly demonstrates that such actions are warranted. We believe that an expanded and coordinated research agenda must serve as the basis from which to proceed in the future.

Business should be mindful of global climate questions as a policy matter due to public interest. Business is taking this issue seriously. At present, however, it is unrealistic to expect industry to make significant long-term commitments based on incomplete and conflicting data. Business planning is based on consumer needs, capital costs, and technological and competitiveness considerations. Any long-term planning includes risk assessments, energy availability and price assumptions, and other prudent considerations. We cannot

afford to place the competitiveness of our manufacturing sector in jeopardy based on any speculative theory. Another point to note is that although research planning is usually long-term, typical planning for capital expenditures, even for large companies, is usually 3-5 years.

An excellent example of one of the difficulties businesses have in planning is the use of CFCs in refrigeration. The U.S. Environmental Protection Agency (EPA) is committed to regulate and eliminate CFCs for all refrigeration uses in an effort to contact stratospheric ozone depletion. However, the U.S. Department of Energy calls for CFCs to be used in refrigeration for energy efficiency purposes. To date, CFCs are the most energy efficient substances for refrigeration in residential and commercial refrigerators and freezers. This example illustrates the complexity of the environmental/energy efficiency relationship.

NAM supports integrated scientific research into all physical, chemical, and biological processes that interact in the earth's climate system. A nationally coordinated climate research program is essential. NAM hopes that any research program evaluates existing programs as well as deficiencies in the on-going domestic research. Additionally, the NAM believes that an integrated research program involving Federal agencies should be coordinated through the Executive Branch with particular emphasis on the Office of Management and Budget. We were pleased to see, for example, that the government Interagency Committee on Earth

Sciences compiled a comprehensive global climate research plan and made these recommendations part of the President's FY 1990 budget.

The already established Federal Coordinating Council is the logical vehicle for this activity, but it should include input from researchers in the private sector, and from academia. If it is totally a government function, the council loses the benefit of outside thinking. If private and academic input is strictly an advisory function, the government is not required to consider the advice with the same strength that it might have if the participation were a direct part of the council's deliberations. We, therefore, believe the private sector input should be an integral part of government research and such research should be coordinated with international scientific organizations.

NAM believes efficient use of energy should be a cornerstone of a national energy policy. The industrial sector has been the leading force for energy conservation in the United States. As the worldwide price of energy rose, industry found ways to use less energy, and to use it more efficiently. These powerful market forces will continue to be the main stimulus for conservation, however, environmental issues will now also influence energy decisions. The management of energy for industrial use remains a strategic concern with implications for productivity, U.S. competitiveness overseas and the capability to meet domestic energy needs.

We as industry continue to increase our energy efficiency by doing things that make sense in their own right. A free energy market is our best guarantee of a secure energy future. However, NAM believes the federal government has a role to play in conservation, such as education, technology transfer, limited and voluntary data collection, and financial support for long-term, high-risk research and development where private sector incentives are inadequate. With the voluntary help of various trade associations, government can develop a data base on industrial energy use and efficiency, and report on progress. Government should be a conduit for information on promising non-proprietary technologies. NAM is concerned that radical fluctuations in energy research and development appropriations operate to the detriment of prudent research and development management. Congress and the Administration should make greater efforts to arrive at a consensus as to the appropriate level of energy conservation research and development funding.

NAM believes that the most efficient way to encourage industrial energy conservation investment is to promote a good overall investment climate in the economy. Industry, in response to market forces and investment climate, will make the most cost-effective and appropriate conservation investments. Energy conservation investments have been made and will continue to be made when they are economically feasible.

The imposition of mandatory conservation standards for industrial buildings and equipment is unnecessary primarily because they cannot recognize the diversity of industrial processes, cannot keep pace with

emerging technologies, and because industry has consistently responded to life-cycle costing as a determinant of economic feasibility. NAM encourages elimination of government programs to develop performance standards for new and existing industrial buildings and of mandatory requirements to promote the energy efficiency of industrial motors and pumps and other industrial equipment.

In conclusion any solutions to this global issue should be global in nature. Unilateral actions by the United States could be insufficient and at the same time prove to be significant deterrents to the United States' industrial positioning in international markets. Therefore, we strongly urge focusing on only multinational solutions and a careful study of the cost and environmental impact of any proposed solutions.

Thank you for the opportunity to share our thoughts on global climatic issues. We look forward to working with the United States Senate Committee on Energy and Natural Resources on this issue in the 101st Congress.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
STATEMENT ON S324 FOR THE
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
MARCH 14, 1989

Mr. Chairman and Members of the Senate Committee on Energy and Natural Resources, we are pleased to present this statement for inclusion in the written record for the Committee hearing on S. 324 held on March 14, 1989.

The National Electrical Manufacturers Association (NEMA) is the principal national trade association for manufacturers in the electrical industry. NEMA represents over 600 domestic manufacturers of products used in the generation, transmission, distribution and end-use of electrical energy. One of the nine divisions within NEMA is the Lighting Equipment Division. Its member companies manufacture 90% of lamps, ballasts, fixtures and emergency lighting sold in the US. Members of the Lamp Section include Duro-Test Corp., General Electric, GTE Sylvania, OSRAM Corp., Philips Lighting Co., and Venture Lighting International.

S. 324 amends Part B of title III of the Energy Policy and Conservation Act (Act) to include in section 322(a) "Incandescent lamps which are the predominant consumers of energy used for lighting in the commercial, industrial, and residential sectors," and "Fluorescent lamps which are the predominant consumers of energy used for lighting in the commercial, industrial, and residential sectors."

The language in the bill addressing lighting is unclear. It can be interpreted to mean two different things. One possible interpretation is that incandescent and fluorescent lamps are the major consumers of energy used for lighting and therefore are being considered for inclusion in the Act. A second interpretation is that those incandescent and fluorescent lamp types which are widely used and therefore consume a major portion of the energy used for lighting should be included in the Act.

Incandescent lamps are used predominantly in the residential sector; fluorescent lamps are used predominantly in the commercial and industrial sectors. There are thousands of lamp types that have been developed within these two broad lamp categories, and each one differs in wattage, bulb shape, color rendition and/or application.

Lamp efficiency, traditionally, is given by dividing the light output in lumens by the input watts. The result is expressed in lumens per watt (lpw). Since this value is not a percentage, the term "efficacy" is used to identify it. Lamps with high efficacy do not necessarily save energy. The following

are examples using traditional lamp technology:

- o A 100 watt incandescent general service (household) lamp has an efficacy of 17.5 lumens per watt (lpw). A 75 watt lamp has an efficacy of 16.1 lpw. The continued use of the 100 watt lamps insures a more efficient use of electricity to produce a given amount of light. The less efficient 75 watt lamp saves 25 percent energy, but with a sacrifice in light output.
- o A 40 watt cool white fluorescent lamp (a traditional lamp used for general office lighting) is by far the most popular fluorescent lamp. A 34 watt energy saving retrofit lamp with its associated ballast is approximately 3 percent less efficient, but it saves approximately 16 percent of the system energy. Since the average fluorescent fixture in many commercial buildings uses four such lamps, the use of 34 watt lamps, despite their lower efficiency, results in a savings of 18 to 24 watts per fixture with a 10 to 15 percent decrease in light output.
- o An incandescent reflector lamp (a traditional lamp used for retail store displays) is inefficient in terms of lumens per watt. If it were replaced with a more energy efficient "household" incandescent lamp, the result would be wasted light, scattered in all directions. The purpose of the reflector lamp is to direct light onto the display. Replacement with a lower wattage energy saving, reflector lamp will result in very similar lighting, but with a 10 to 20 percent energy saving.

Since many lamps are used for specific applications and may not necessarily be as efficient as other similar lamps, promulgating requirements that cover all the lamp types could eliminate those special lamps. Such lamps should be exempt. For example, a 40 watt cool white deluxe lamp, used for its better color rendition qualities over the meat counter in a supermarket, is relatively inefficient (56 lpw) compared with a regular 40 watt cool white (79 lpw) used in office spaces. Changing the deluxe lamp to the regular lamp on the basis of energy efficiency will not save energy (wattage is the same), and it will make the meat look unappetizing and unsalable.

Members of the NEMA Lamp Section understand current energy concerns, but legislators and regulators have to be aware that generalized requirements for lamp efficiencies will not necessarily save energy or use it efficiently, and that of the thousands of lamp types, only a few consume a large portion of the energy used for lighting. It would be more prudent to address the most popular ones currently used in existing buildings. Such a focus would allow regulations to address those lamps which use a major portion of the electric energy consumed by lighting.

Thank you for this opportunity to present our views regarding S. 324. We would be pleased to provide technical assistance to members of Congress and Congressional Staff in establishing a national energy policy relating to lamps and lighting. Last year, NEMA worked with Congressional personnel in composing and passing the National Appliance Energy Conservation Amendments of 1988 which address fluorescent lamp ballasts (100th Congress, S. 2167).

PUBLIC CITIZEN

Buyers Up ☐ Congress Watch ☐ Critical Mass ☐ Health Research Group ☐ Litigation Group

TESTIMONY

of

Nancy Rader
Energy Policy Analyst
Critical Mass Energy Project
- Public Citizen

before the

Committee on Energy and Natural Resources
U.S. Senate
Washington, DC 20510

March 14, 1989



Public Citizen
3/14/89

Page 1

Introduction and Summary

Public Citizen is a non-profit research and advocacy organization founded by Ralph Nader in 1971 to address a broad range of consumer and environmental issues. The Critical Mass Energy Project is Public Citizen's energy policy arm.

Public Citizen urges the committee to support a substantially increased R&D budget for renewable energy technologies. Ideally, the budget should be increased to 1980 levels. However, in consideration of severe budget constraints, we urge the subcommittee to minimally support funding at 1985 levels (inflated to today's dollars).

Additionally, Public Citizen believes that a multi-year authorization bill is essential in order to restore stability to the renewable energy research program and to ensure its maximum efficiency. The authorization bill should direct the DOE to focus on the near-term commercialization of renewable technologies as well as long-term, high risk research in order to reap the benefits now of the technologies which are ready for the market, but which remain under-utilized.

After energy efficiency, renewable energy sources offer the greatest near-term hope for reducing fossil-fuel-generated carbon dioxide emissions that are causing global warming. They also provide a domestic energy source which could realistically end U.S. dependence on foreign oil, as well as displace the need for nuclear power which has proven to be both expensive and dangerous. Renewable energy could accomplish these goals within 20 years if backed by a commitment from the federal government. This year's budget for renewable energy R&D can begin to put the U.S. back on that path from which it has strayed since 1981.

The following data is from Public Citizen's September 1988 report, Turning Down the Heat: Solutions to Global Warming. A copy of this report is on file with committee staff. It also contains information that will be contained in an upcoming report by Public Citizen.

Renewable Energy Contributes Significantly to the Current U.S. Energy Supply

Renewable energy technologies have made significant advances in the last eight years, despite drastically reduced federal support for research and development. Most renewable technologies are now competitive with conventional supplies, and, together, they represent 9% to 10% of domestic energy supplies (depending on hydropower production levels), and 7.5% to 8.5% of total energy use in the U.S.

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The Potential of Renewable Energy in 2000 and 2010

Public Citizen estimates that renewable technologies are likely to contribute 14 quads, or 15% to 20% of total U.S. energy consumption in the year 2000, depending on whether or not the U.S. increases the efficiency with which it uses energy. This estimate is conservative. What could actually be achieved is much greater, especially given a more favorable climate for development. Such a climate would include enhanced federal support for research and development programs.

Renewable energy could conceivably satisfy virtually all U.S. energy needs by the year 2010 if the government chooses to pursue that goal. According to a 1985 report of the DOE's own Energy Research Advisory Board (ERAB) and the DOE's 1985 Renewable Energy Research and Development Outlook, research advancements from some 43 technologies would allow renewable energy to achieve competitive viability in up to 80% of the national annual demand for energy in the year 2010. Further, total energy demand could be greatly reduced by that time if energy efficiency is promoted simultaneously with renewables.

Direct Link Between R&D and Potential Energy Supply

Government studies have shown that there is a direct link between federally-supported research on renewable energy technologies and the supply potential of those technologies.

The GAO reported in 1987 that the development of renewable technologies has been substantially hindered by drastically reduced federal R&D because the private sector does not compensate for DOE's reductions. As a result of the administration's policy, U.S. technology development has been delayed.

The ERAB report mentioned above recommended that the federal R&D program be maintained at then-current (1985) levels, emphasizing the importance of stable funding. The relative stability of the previous two years (1984 and 1985) permitted the DOE to "take steps in that direction," it said. Unfortunately, this stability did not continue, as the Reagan-Bush administration and Congress cut the renewable energy budget by another 50% since then.

ERAB's recommendation that funding be continued at 1985 levels was based on its presumption that there is a "long lead time before there is an urgent need for large supplies of energy from the renewable resource." This is no longer the case if the U.S. is seriously concerned about mitigating the effects of

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global warming. Thus, 1985 funding levels should be considered the minimum necessary.

The severe energy R&D cutbacks of the Reagan Administration--and now apparently those of the Bush Administration--reflect a "free market" approach to energy policy that shifted the emphasis of the renewable energy program away from near-term market development to long-range basic research of energy concepts.

The flaw in the Reagan/Bush approach is that it incorrectly assumes that renewable energy industries are capable of using basic research and applying it towards practical applications and commercial designs. It further assumes that renewable technologies, once they are proven, will be able to penetrate the market. This is not the case for solar industries because they are primarily composed of under-capitalized small businesses, and because of various institutional barriers.

The "long-term, high-risk" approach also overlooks the fact that the market cannot gauge the non-price benefits of renewable energy, such as their positive effect on the environment, human health, the economy, and national security.

Renewables Can Alleviate Global Warming

In our earlier report, we documented how a combination of renewable energy, energy efficiency, and natural gas have the potential to displace fully two-thirds of the carbon dioxide produced by coal and oil in the non-transportation sectors by 2000.

While renewable energy technologies now contribute about 6 quads of energy to the nation's energy supply, they are likely to contribute 14 quads in 2000. Assuming that renewable energy displaces all other sources of fossil energy proportionately, one quad of energy displacement would reduce carbon dioxide emissions by about 75 million tons.

Based on this calculation, additional renewable energy supplies will displace at least 600 million tons of CO₂, or 8% of the total amount projected to be produced in 2000. This projection is based on the conservative estimate of what can be expected from renewable technologies, and not what could be accomplished with a more substantial R&D budget and other supportive public policies.

Renewable Energy Technologies Deserve Parity with Nuclear Power

It is peculiar that many promising and disparate renewable energy technologies are thought of as essentially one resource--

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"renewables," or "solar," and that they are funded at a combined level that is far lower than one, failing, technology--nuclear power. In 1989, nuclear energy fission and fusion programs (not including nuclear waste research and uranium enrichment losses) each received about \$350 million in comparison to total funding for renewables of less than \$113 million.

Biomass energy alone is rapidly approaching an energy production level rivaling that of nuclear power. More importantly, many renewable energy technologies individually hold far greater promise than nuclear power for displacing fossil fuels causing global warming. Biomass energy, for example, could easily double by the year 2000 to 8 quads. Solar building technologies could increase manifold to displace up to 8 quads by 2000. It is difficult to imagine a utility ordering one new nuclear plant, let alone doubling nuclear capacity within 10 years.

Since renewables (combined as well as each one separately) have far greater potential than nuclear power to reduce carbon dioxide emissions, they should be given priority in the R&D budget. Minimally, they should receive funding on an equal basis with nuclear power programs. However, since federal funds are limited, additional funds for renewables should come from nuclear fission and fusion programs. Further, due to the waste and safety problems of nuclear power, remaining funding for nuclear R&D should go towards waste clean-up and decommissioning, and to pay off the accumulated debt from uranium enrichment subsidies.

Conclusion

Based upon the direct link between R&D and the potential supply of renewable energy, and upon the fact that developing renewable energy technologies must be an essential component of any strategy to reduce emissions causing global warming, we strongly urge the committee to restore R&D funding minimally to 1985 levels. Additional funds should come from the R&D program for nuclear power.

Additionally, Public Citizen urges the committee to support a multi-year authorization bill to restore stability to the renewable energy research program and to ensure its maximum efficiency. The authorization bill should direct the DOE to focus on the near-term commercialization of renewable technologies as well as long-term, high risk research so that renewable energy technologies that are now ready for the market can be properly utilized.

Solar Energy and the Greenhouse Effect

POWER KINETICS, INC. (PKI)

Dr. William E. Rogers

March 10, 1989

Solar energy is the source of all the fossil fuels on earth. From the dawn of photosynthesis in prehistory, plants absorbed the sun's rays to release oxygen from carbon dioxide. The carbon was used in growth. Many of these plants were trapped underground, and over millions of years were fossilized and transformed into coal, oil, and natural gas. Ultimately, these resources became mankind's energy inheritance.

With this wealth of energy, industrial nations established luxurious standards of living, and achieved modern engineering marvels. The same nations, in haste, have used these resources wastefully. Higher and higher levels of carbon dioxide have been released into the atmosphere -- simply by burning increasing amounts of fossil fuels.

Excessive reliance on fossil fuels has brought us to a point where we can now forecast the extinction of these non-renewable supplies.

Equally alarming is the fact that our reliance on fossil fuels has intensified the global greenhouse effect. Unless we make dramatic changes in our patterns of energy use and production, we may soon observe climate changes that would cause tragic disruptions in life around the world.

Carbon dioxide emissions are the single largest cause of the damaging greenhouse effect. The average person in the United States adds 23 tons of carbon dioxide to the atmosphere each year by burning oil, gas, and coal. ^[1] This combustion also produces oxides of sulfur and nitrogen, which in turn create the acid rain problem.

We can remedy this situation. One part of the solution is to practice conservation and promote better long-term planning regarding our fuel resources. The other part of the solution is to use modern solar technologies in combination with coal, oil, and natural gas. Solar-participating fuel production, a proven reality in research, is now ready for commercial development.

PKI finds it encouraging that excellent long-term technologies are already known, but we need a change in priorities. For example, the entire U.S. DOE solar thermal budget for 1989 is equivalent to the amount of oil imports consumed in just three hours! ^[2]

The solar industry is a means to a better standard of living for our children. To diminish the greenhouse effect, legislation may be required, not merely to enhance the development of solar energy, but to redirect our national energy policy from short-term profits to long-term good sense.

In addition to initiatives that promote energy conservation and incorporation of passive solar technologies into buildings, we must emphasize:

- Displacement of carbon dioxide emissions.
- Use of equipment with attractive energy profit ratios.
- Cogeneration technologies that cascade energy use.
- Clean, solar-participating fuel production.
- Use of the unique capability of solar energy to clean up hazardous waste.

These points will be discussed later in this paper. Because our country is so motivated by short-term rewards, it is necessary for legislated market incentives to align short-term commercial progress with long-term goals.

By the application of existing solar energy technologies, we can combine our finite fossil fuels with unlimited solar energy in ways that will begin to diminish the greenhouse effect today and brighten the energy future of tomorrow. With research done during the past decade, this has become possible...and now we have reached the moment when it is necessary.

Responsible energy husbandry always begins with conservation. Doing more with less permits withdrawals from our energy savings account to pace our nation's progress with the time needed to develop new technologies. Our children's energy appetite will require even more advanced energy harvesting technologies. Oceans and plants also need the time to absorb what we exhaust.

One important aspect of energy conservation is cogeneration of electricity, putting the rejected heat to other uses. Power-generating equipment, using diesel engines or turbines, converts only about 30% of the energy in the fuel to electricity, and rejects large amounts of heat energy. This rejected energy can be "cascaded" through other processes at ever-decreasing temperatures and made available for conditioning water and space, for drying, or for other industrial processes.

Every building can benefit from passive energy design technologies to maintain light levels and comfort. Economics now determine which proven concepts can be incorporated in new construction or retrofitted in existing buildings. In regions of the country blessed with sunny days, active solar equipment available today can greatly diminish fossil fuel use.

Photovoltaic cells convert sunlight directly to electricity, and operate without attention or negative impacts on the environment. They are currently too expensive to compete with large fossil fuel based power plants, but the costs are being steadily reduced. Thin film photovoltaic technologies can potentially deliver 15% of the available sunlight as electricity, and with single crystal cells we can eventually double that. In certain locations, (e.g., radio repeaters on mountain tops) they already are, and will remain the best choice.

Other solar technologies with higher performance at lower cost are more appropriate for large power plants.

On the earth's surface, the intensity of solar energy is just right for life to flourish, but it is too diffuse for efficient power generation. However, by intensifying sunlight, the energy industry has the potential to do much more than has been accomplished by burning fossil fuels. Concentrating solar collectors give us this capability.

Power Kinetics, Inc.

Power Kinetics, Inc., manufactures the world's largest point focusing solar collector, a 3,200 ft² PKI Square Dish collector that can generate steam and deliver it to a central point at very high temperatures (see Figure 1). Its performance can be very high, >80%.^[3] Built out of steel and delivering steam, the energy profit ratio of this solar collector is 49 in California. That means that for all the energy invested in the materials, their fabrication, transportation, and erection, the collector delivers 50 times that amount in 25 years.^[1] By comparison, in the U.S. today, the energy profit ratios of coal, gas, oil and nuclear power are well below ten.^[4]

But what if you don't live in a desert?

Solar energy is not always available when and where energy is required. One prevalent misconception is that solar systems must include stored thermal energy to compete with conventional energy sources. Stored thermal energy degrades, though, and is expensive. Since fossil energy is stored solar chemical energy, another approach would be to use solar in conjunction with fossil fuels.

By locating a coal burning power plant with solar collectors in the desert, every pound of steam generated by the sun can be utilized. Coal can be used to supplement the available sun when more power is needed. The answer is to use solar energy in combination with other fuel sources.

In the U. S. today, burning coal provides 57% of the energy used to generate electricity. [5] Since it is primarily carbon, burning coal maximizes the amount of carbon dioxide exhausted into the air. Also, because coal does not burn cleanly, cleaning of flue gasses requires additional energy. A noble goal for solar energy would be to displace coal as a source of electricity.

But there is now another option.

David Gregg, at Lawrence Livermore Laboratory in California, has used concentrated solar energy to gasify coal. This "is the cleanest and most efficient way to convert our plentiful coal resource into combustible gas. The process also stores a large portion of the solar energy in the product gas." [6] The syngas (carbon monoxide and hydrogen) that is produced is the basis for a large part of the chemical industry. It is the starting point for synthesis of ammonia, methyl alcohol, and various monomers of plastics -- applications where industry now uses limited reserves of natural gas. Syngas can also be converted into methane, and distributed around the country via natural gas pipelines. It can also be converted into gasoline for transportation.

PKI views this as a promising breakthrough, and has proposed commercial development of this process through the Small Business Innovative Research Program. [7] In fact, there is something like alchemy in modern solar technology. In this example, you take "bad" coal, with its grimy associations add sunshine, literally, and thereby produce a cleaner fuel and a valuable chemical feedstock. In another example, Sandia National Laboratories, Albuquerque and the Solar Energy Research Institute have demonstrated unequivocal success in completely destroying dioxins and other hazardous wastes. [8]

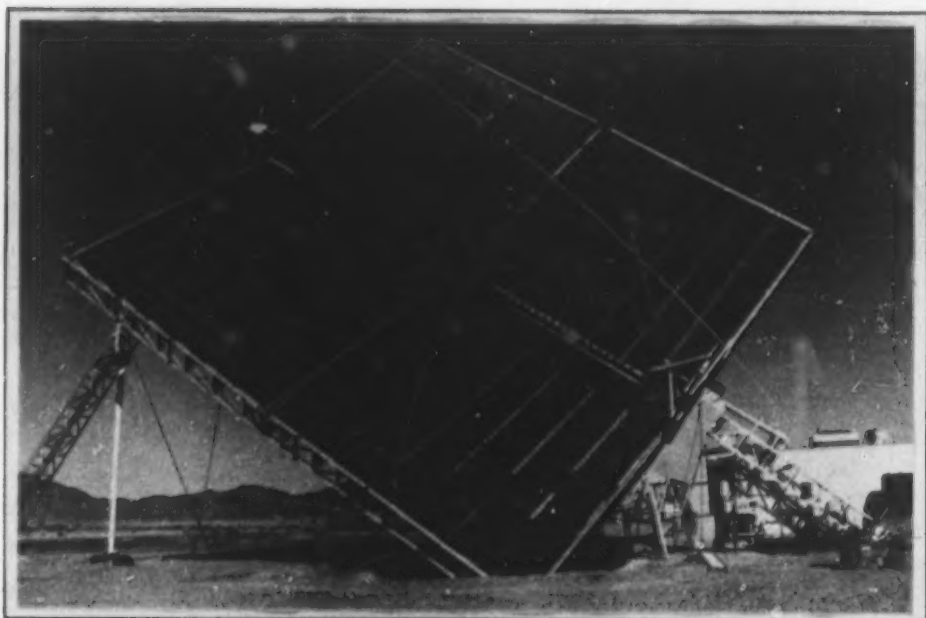
The most attractive feature of producing cleaner fuels with the sun is the ability to transport solar energy from the southwest to other regions where sun and land are more limited. There, it can be used to generate electricity in small cogenerating powerplants and the rejected heat captured. Up to 70% of the energy available to a collector in the southwest can be utilized in this way. Eventually, solid state devices such as fuel cells and thermophotovoltaic devices will be developed which will allow individual homes to effectively use renewable fuels when they need heat or electricity. PKI is preparing to develop this kind of technology.

This technology would extend the supply of coal by almost twice and promote its clean use (the solar reactor is a closed system). At the same time it would halve the amount of carbon exhausted to the atmosphere. Solar gasification of coal is only one process. Many others have been demonstrated in U.S. solar laboratories.

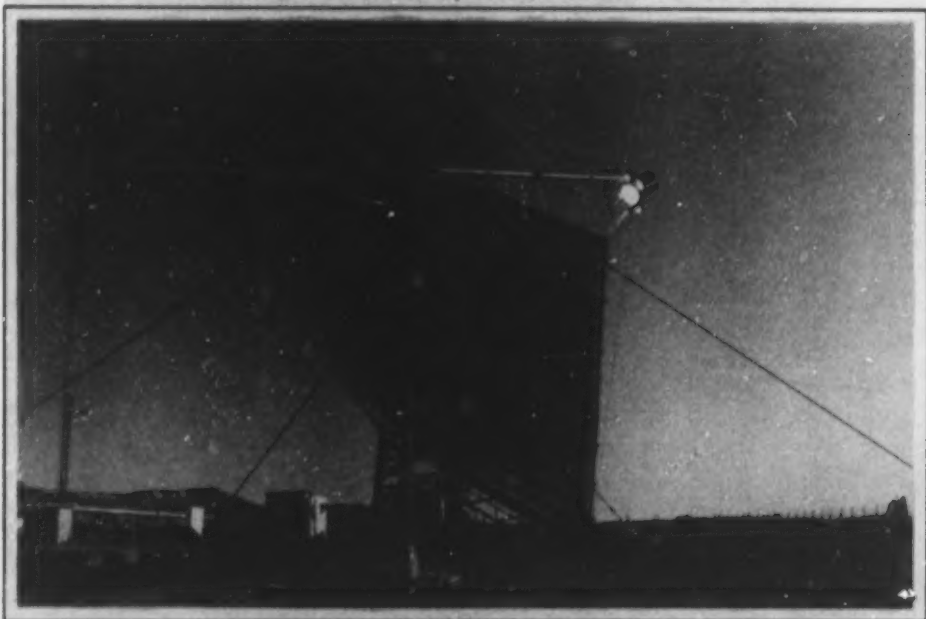
Today we must use the sun's energy more wisely, more efficiently than we did yesterday. And we have to persist in these efforts tomorrow, through the next decade, and the next century -- to allow life to flourish on our planet.

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Power Kinetics, Inc. 300 m² Square Dish Solar Collector
2:00 PM position, front view



Power Kinetics, Inc. 300 m² Square Dish Solar Collector
2:00 PM position, rear view

Photos taken while unit was under test at Sandia National Laboratory, Albuquerque, NM

FIGURE 1



Statement of the U.S. Chamber of Commerce

ON: THE NATIONAL ENERGY POLICY ACT OF 1989
(S. 324)

TO: SENATE COMMITTEE ON ENERGY AND NATURAL
RESOURCES

BY: SUSAN C. MOYA

DATE: MARCH 31, 1989

— The Chamber's mission is to advance human progress through an economic,
political and social system based on individual freedom,
incentive, initiative, opportunity and responsibility.

The U.S. Chamber of Commerce is the world's largest federation of business companies and associations and is the principal spokesman for the American business community. It represents nearly 180,000 businesses and organizations, such as local/state chambers of commerce and trade/professional associations.

More than 92 percent of the Chamber's members are small business firms with fewer than 100 employees, 59 percent with fewer than 10 employees. Yet, virtually all of the nation's largest companies are also active members. We are particularly cognizant of the problems of smaller businesses, as well as issues facing the business community at large.

Besides representing a cross section of the American business community in terms of number of employees, the Chamber represents a wide management spectrum by type of business and location. Each major classification of American business—manufacturing, retailing, services, construction, wholesaling, and finance—numbers more than 10,000 members. Yet no one group constitutes as much as 32 percent of the total membership. Further, the Chamber has substantial membership in all 50 states.

The Chamber's international reach is substantial as well. It believes that global interdependence provides an opportunity, not a threat. In addition to the 59 American Chambers of Commerce Abroad, an increasing number of members are engaged in the export and import of both goods and services and have ongoing investment activities. The Chamber favors strengthened international competitiveness and opposes artificial U.S. and foreign barriers to international business.

Positions on national issues are developed by a cross section of its members serving on committees, subcommittees and task forces. Currently, some 1,800 business people participate in this process.

STATEMENT
on
THE NATIONAL ENERGY POLICY ACT OF 1989 (S. 324)
for submission to the
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
for the
U.S. CHAMBER OF COMMERCE
by
Susan C. Moya*
March 31, 1989

The U.S. Chamber of Commerce, the world's largest federation of businesses, state and local chambers of commerce and trade and professional associations, appreciates this opportunity to comment on S. 324, the National Energy Policy Act of 1989. The primary goals of S. 324, a comprehensive global climate change proposal, are reducing carbon dioxide by 20 percent by the year 2000 and other "greenhouse gases" as quickly as possible to slow the pace and extent of global climate change.

The purpose of this statement is to share the Chamber's views and proposed strategies for addressing the potential of global climate change. The Chamber suggests appropriate roles for conservation, nontraditional energy sources, e.g., solar, wind and geothermal, and new goals for energy research and development. This statement also discusses areas where the Chamber's strategies and S. 324 fundamentally differ and concludes by noting areas in S. 324 that would benefit from additional review.

Introduction

The Chamber believes that any man-made climate change is cause for the most serious concern and action -- the right action -- because the wrong action could create more severe consequences. The Chamber commends the Committee for its efforts to learn more about this unusual and complex issue prior to addressing it by legislation.

* Susan C. Moya is Manager, Energy and Natural Resources Policy.

As a basic premise, the Chamber believes that it would be imprudent to disregard or discard established energy and environmental policies in favor of new policies generated solely by concerns over climate change. It also believes that global climate change is an international issue that requires international cooperation. No one country's actions, however ambitious, can significantly affect global climate change. International cooperation is essential.

Global climate change is a major scientific and political issue. Although numerous articles on the subject have been written within the past year, including cover stories in both Time and Newsweek, conflicting information abounds.

There is no scientific doubt, however, that the greenhouse effect is real and can result in global warming. There is a broad range of opinion as to how much climate change will occur, when it will happen or where its effects will be most evident. Evolving models are designed to predict average global temperature rise and when this rise may occur. Estimates range from one to five degrees Celsius (a large range for the phenomenon) over periods estimated from decades to a century or more. Resulting weather and other changes are inferred from the projected increase in average temperature.

The greenhouse effect has a well-founded scientific basis. It is the trapping of heat in the atmosphere, leading to a rise in the average temperature (hence to changes in global climate patterns). Greenhouse gases, notably carbon dioxide, methane, certain chlorofluorocarbons, and nitrous oxides, trap heat the same way that glass in a greenhouse or in a car on a hot day traps heat. These gases come from a broad range of natural and man-made sources. Records indicate that the amounts of carbon dioxide and other greenhouse gases in the atmosphere have been increasing over modern history. These increases have led to the current great interest and concern over the prospect of global climate change.

If global atmospheric temperatures rise significantly, natural ecosystems, water supplies, agriculture and sea levels will all be affected to varying degrees over time. If unchecked by natural or societal actions, the greenhouse effect could result in climate changes that would affect the way we live and where we live.

Chamber Action Strategy on the Global Climate Change Issue

The Chamber recently distributed to members of Congress its discussion paper Global Climate Change: Cause for Concern, NOT Panic, which suggests parallel courses of action.

The first imperative is to gain a better scientific understanding of global climate change in order to improve the capability to predict and respond to changes, whether naturally occurring or the results of human activities. A prioritization and an institutionalization of federal interagency global climate change research efforts also are steps toward this goal.

In tandem, the second course of action is to take those steps that make sense now, on their own merits, regardless of whether the global atmosphere is warming. Of course, the U.S. must play its fair part in such activities, but it is important to recognize that this is a global problem that requires international cooperation.

Need for Coordinated Federal Research

Currently, as many as nine national and international organizations are involved in global change research activities. No fewer than 12 U.S. federal departments and agencies are attempting to understand the global ecosystem. Clearly, these organizations need prioritized goals, plans and a framework for their research activities. All federal global climate change research activities should be identified in an integrated manner in the

federal budget, such as was recently done by the government Committee on Earth Sciences in its recommendations for the President's Fiscal Year 1990 budget.

Reliable information, predictions and assessments of the complex phenomena of the global system are important. For example, global warming could require changes in agricultural policies, modes of energy production and usage, use and protection of natural resources and coastal zone management. The Chamber encourages scientists around the world to work toward a better understanding of global climate change.

Sustained Economic Growth with Decreased Emissions Possible

As global climate change efforts are evaluated, it is important to keep in mind that the U.S. sustained a long period of economic growth with diminishing emissions of carbon dioxide. Figure 1 (attached) shows changes in carbon dioxide emissions and Gross National Product (GNP) from 1973 to 1988. Emissions peaked about 1979, dipped and then rose again in 1988. However, at the same time, GNP increased steadily. More informative, Figure 2 (attached) shows the ratio of emissions to GNP from 1973 to 1988. Over the entire period, the ratio decreases, showing increased economic output with decreased emissions. This experience is a lesson for the rest of the world, showing that sustainable economic development need not be accompanied by greatly increased emissions. The challenge is to identify what was done correctly and implement such policies elsewhere.

Unilateral Efforts Will Not Work

Economic growth in developing nations would make any unilateral effort by the U.S. to reduce carbon dioxide emissions futile. While the per capita generation of carbon dioxide in developed countries is, of course, much higher than in developing countries, if China alone were to meet its goal of raising its per capita GNP to only 15 percent of the U.S. figure,

just the increase in carbon dioxide emissions in China would about equal emissions from all the coal consumed in the U.S. Similarly, if India maintains its current per capita emissions, its population growth will cause a similar increase in carbon dioxide emissions by the middle of the next century. Even if the U.S. were to take very drastic steps to reduce carbon dioxide emissions, its doing so would not reduce worldwide emissions.

Unanswered Questions

As global climate change research activities are being formulated, the Chamber hopes that the following questions will be given high-priority consideration. The answers will help to provide the understanding to quantify the contribution of society's activities to global climate change and allow everybody, worldwide, to be prepared to act accordingly.

Some questions that must be addressed are:

- o What effects do societies have on global climate change compared to the natural forces of weather and the small (but real) natural changes in climate as the planet grows older?
- o What are the principal uncertainties in the scientific bases for global climate change predictions and the consequences of those uncertainties?
- o What are the anticipated future distribution and sources of "greenhouse gases"? How might this mix be changed without undue economic, environmental and social costs? Do those affected understand these costs?
- o What is the likely range of effects on energy development? Is the importance of energy development, which enables us to produce the basic necessities and amenities of life, duly recognized?

- o What can the rest of the world learn from the U.S. in order to achieve economic growth and well-being with virtually no increase in carbon dioxide emissions?
- o Which of the many proposed mitigation strategies will be effective? How do we avoid wasting effort, much less doing the wrong thing?

A Proposed Course of Action

The role of science in this issue is to provide direction and scope for policy development. However, a number of things should be done now, parallel with the above efforts. Policy that makes sense, on its own merits, can be adopted now. And, when more is known, we will better understand what other actions to take.

The Chamber urges the U.S. immediately to lead the way to:

- o Educate people around the world about global climate change and the choices that may be necessary to avoid it.
- o Support international cooperative research to advance the ability to predict the effects of such change and take needed moves to alleviate or avoid them.
- o Implement actions to mitigate climate changes caused by man and assure that they make economic, social and environmental sense on their own merits. The costs of changing human life-styles must also be factored.
- o Assist developing nations in joining global efforts while maintaining their economic growth by increasing research and development and trade incentives, by sharing land and forest management, by new agricultural practices and by other means.
- o Remove unnecessary impediments to the adoption of alternative energy technologies and energy conservation.

Unilateral actions also should be taken. They include:

- o Encouraging more energy conservation.
- o Striving to gain acceptance of nuclear energy.
- o Continuing to explore alternatives to fossil fuels, e.g., wind power, photovoltaic cells and solar collectors.

National Energy Policy

The Chamber believes that a national energy policy based on the free-market system can best assure energy security and balance economic growth and environmental protection. The contributions from all domestic energy resources (coal, oil, natural gas and uranium) and from conservation should be maximized and the development of technologies that improve fuel efficiency should be encouraged.

Conservation's Role

A renewed national commitment to conservation of energy resources and the efficient use of energy by all consuming sectors -- industrial, transportation, commercial, residential and governmental -- is needed and strongly supported by the Chamber. Government and industry should work to increase public awareness of the need for energy conservation and ways in which it can be cost-effectively achieved. Conservation can reduce the need for new energy supplies, extend the availability of traditional supplies and provide more time for the development of alternative and new sources. However, resolution of the country's energy or environmental problems cannot rely solely on conservation.

Industry must make every effort to increase its energy efficiency and recognize that it is in its economic interest to do so. But price and availability of supplies, not government regulation or mandatory standards,

should be the principal factors in determining levels of industrial energy usage. The imposition of mandatory conservation standards is unworkable and ineffective. Such standards cannot recognize the diversity of industrial processes and conservation results already achieved.

In the transportation arena, the Chamber believes that mass transportation, including van-pooling, car-pooling, bus or other modes that can be demonstrated to be energy and cost-effective, should be emphasized. However, their use should be voluntary, and government should not restrict individual choice among competing transportation modes.

Greater progress can be made in making buildings more energy efficient. All building owners and occupants -- industrial, commercial, residential and governmental -- are encouraged to invest in and use cost-effective measures to improve heat retention in the winter and heat rejection in the summer. Architects, engineers and other design professionals, along with builders and contractors, can increase their capacity to design and build energy-efficient structures. Building codes that contain performance standards for more energy-efficient structures are supported by the Chamber, if those codes are set through a voluntary consensus process involving representatives from all sectors.

Role of Nontraditional Energy Sources

Governmental efforts should also address the development of nontraditional sources of energy, such as coal gas and liquids, oil shale, solar, oceans, wind, geothermal, advanced nuclear technologies, low-head hydro and biomass fuels.

For the foreseeable future, contributions from renewable energy resources will not be significant, largely because they cost more than fossil fuels. And while hydroelectric power is used widely, the U.S. is running out of places to install more plants, and there are serious environmental and cost concerns associated with this energy source.

Renewable energy resources now constitute about nine percent of the nation's energy supply -- half of this from hydroelectric resources and a large fraction of the remainder from burning wood products. With the help of advanced research, the newer renewable technologies options -- such as geothermal, wind, photovoltaics, solar thermal, passive and active solar buildings and biomass fuels -- are expected to make increasing contributions in the future. Today, however, geothermal energy could provide only enough power to supply a city less than half the size of Washington, D.C., and wind energy's total contribution is sufficient to supply a city the size of Sacramento, California.

Energy conservation has effectively reduced the need for new supplies of energy in the U.S. Since 1972, the cumulative effect of conservation efforts is an estimated reduction in energy use of 29 quads per year, which amounts to more than one-third of U.S. current annual energy consumption. Significantly, this reduction was achieved without massive government programs or regulations. Conservation investments will continue to be made when they are economically feasible and when new technology developments are realized.

Areas Where Chamber Strategies and S. 324 Fundamentally Differ

Having stated the Chamber's views on global climate change, strategies for action, energy conservation and nontraditional energy sources, it is clear that there are a number of broad areas in which the Chamber's views and S. 324 fundamentally differ. They include:

- o S. 324's goal is to reduce unilaterally carbon dioxide emissions by 20 percent by the year 2000 and other greenhouse gases as quickly as possible to slow the pace and degree of global climate change.

The Chamber believes that a better strategy is to take those actions that make sense, on their own merits, for reasons not exclusive of reducing carbon dioxide and other trace gas emissions. These actions will balance such societal requirements as economic growth, sustained energy supplies and environmental protection, including concern for global climate change. As global climate science becomes better defined and more is learned, additional action will become apparent. This strategy will minimize costly mistakes and will not put the U.S. at a competitive disadvantage with nations that are not making similar emissions reductions.

- o S. 324 requires substantial federal government regulation of energy production and use, including provisions to mandate energy efficiency, to reduce the use or to change the mix of fuels and to charge user taxes on certain passenger vehicles and light trucks.

The Chamber believes that mandatory standards, gas guzzler taxes and other provisions in S. 324 that require life-style changes and economic penalties are not the best strategies to win the American public's support on this issue, especially when such actions would be unilateral and have negligible, if any, effects on global trace gas emissions if there is economic growth in developing nations, as discussed previously.

Rather, the Chamber suggests that the U.S. take a leadership role in the international community to investigate vigorously causes and effects of global climate change, mitigation strategies and potential options. The Chamber believes that the American public correctly will view unilateral action by the U.S., as called for in S. 324, as wasteful, insufficient and unfair.

- o In a number of instances, S. 324 calls for federal funding for research, development, demonstration and commercialization.

While the Chamber believes that governmental efforts should address the development of the nontraditional sources of energy, it believes that research, development and demonstration are still a primary responsibility of industry. Federal programs should be established only when a clear public need exists and private-sector incentives are inadequate, such as the current Clean Coal Technology Program. Jointly funded by industry and government and administered by the Department of Energy, this program will improve energy efficiency and add to the protection of the environment. Commercialization of various technologies should be left to the private sector.

Given all of the above, the Chamber believes that there is much in the bill that needs careful review.

Conclusion

Global climate change is neither a partisan nor a philosophical issue. The challenge for everybody, worldwide, is to act accordingly, at the right time. The Chamber believes that its parallel track of research and action strategies provides an appropriate balance between information gathering and steps that we can take now.

The Chamber appreciates this opportunity to present its views on S. 324 and to recommend strategies for research and action on global climate change. It looks forward to working with the Committee on Energy and Natural Resources on this important issue.

Fig. 1: Total Carbon Dioxide Emissions and GNP Variations 1973 - 1988
 Bars = Carbon Dioxide Emissions; Line = GNP

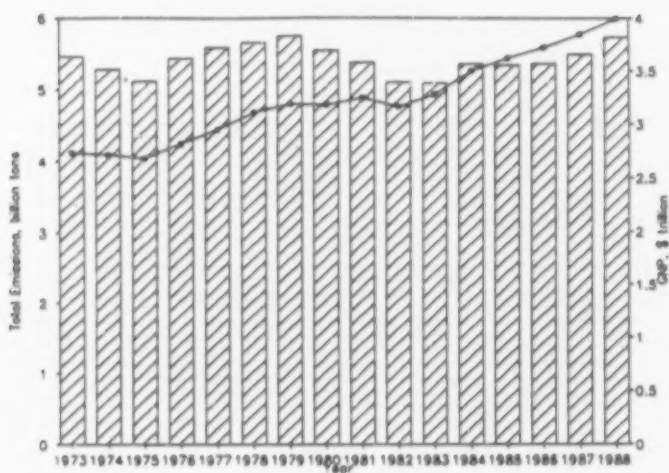


Fig. 2: Ratio (Carbon Dioxide Emissions/GNP) x 1000 from 1973 to 1988



New District Cooling Technologies For Meeting The Challenges of
Global Warming And Atmospheric Ozone Depletion

Testimony for: Senate Committee On Energy and Natural Resources
on: S 324, The National Energy Policy Act of 1989

March 30, 1989

Submitted By:

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Introduction

The environmental crises of global warming and ozone depletion threaten to disrupt life on earth in general and human economies and societies in particular to such an extent that all reasonable and effective means at our disposal should be quickly brought to bear on these problems. The global warming crisis, commonly referred to as the "Greenhouse Effect", is in large part attributable to carbon dioxide pollution of the atmosphere which can be mitigated to a substantial degree by increasing the efficiency with which we produce and consume energy. The potentially catastrophic results of global warming are so severe that extensive changes in our energy supply system are being called for by many highly respected national and international scientific bodies. Due to the very high levels of energy efficiency of technologically advanced district cooling systems and the capacity of such systems to produce building air conditioning supplies with environmentally benign refrigerants in place of chlorofluorocarbon (CFC) refrigerants, any plans for significant changes in our energy supply system designed to halt the progress of global warming and atmospheric ozone depletion should include a much greater level and more rapid pace of development of this technology.

District cooling is a thermal distribution technology comprising a network of chilled water pipes distributing air conditioning to a number of buildings. Using a district cooling system, energy sources or energy conversion technologies which cannot be used in a single building for supplying cooling can be used to supply groups of buildings by centralizing the energy conversion system and removing it from the confines of a single building. District heating is a mature technology which is extensively employed in many European countries, providing heating services for over half of the buildings in a number of these countries. Its counterpart, district cooling, is a much newer and relatively immature technology which is still in need of research and development before it can begin to realize its very large potential for supplying air conditioning to American buildings.

In addition to thermal distribution functions, advanced district cooling systems also encompass thermal production technologies such as cogeneration, heat activated cooling and renewable sources of cooling. Cogeneration is a high efficiency energy conversion process which is defined as the simultaneous generation of both electricity and heat from a single energy conversion process. The heat from a cogeneration system can be used to generate air conditioning in high efficiency, heat activated chillers which do not use CFC refrigerants. Such systems offer very large energy efficiency advantages over conventional alternatives--40 to 60% of the energy used in building air conditioning can be saved by such systems. In cases where renewable sources of cooling are employed, the energy efficiency advantages can be even greater--up to 85% energy savings. Advanced district cooling systems not only can significantly contribute to the simultaneous resolution of both global warming and atmospheric ozone depletion crises but can do so in the near term--4 to 5 years--given sufficient levels of support for technology R&D.

Advanced District Cooling Technology

Advanced district cooling technology provides an essential thermal linkage of building air conditioning loads with low cost and environmentally benign sources of cooling from cogeneration and renewable energy systems. District cooling provides a means by which energy sources and energy conversion processes which cannot be employed in a single building for supplying heating, cooling and electricity can be supplied to groups of buildings by centralizing the energy conversion facilities and removing them from the confines of a single building.

The development of a highly energy efficient, low cost district cooling technology is essential to the use of cogeneration and renewable energy systems for supplying buildings with air conditioning since district cooling systems assemble the thermal loads of many buildings to facilitate the economical sizing and operation of such thermal sources. The availability of advanced district cooling technology will also enable cogeneration and renewable energy systems to take advantage of the load diversity factor characterizing aggregated thermal loads which produces relatively flat load curves looking very much like the heat load curves of industrial plants which tend to be relatively constant, permitting the cogeneration system to achieve a relatively high utilization of its capacity and a much more rapid payback than if it had to respond to typical single building thermal load curves which are dominated by peaks.

The research and development tasks which need to be accomplished in the near term to make advanced district cooling technology commercially available focus on the development of advanced transmission fluids. These fluids include phase change materials such as ice slurries and friction reduction additives.

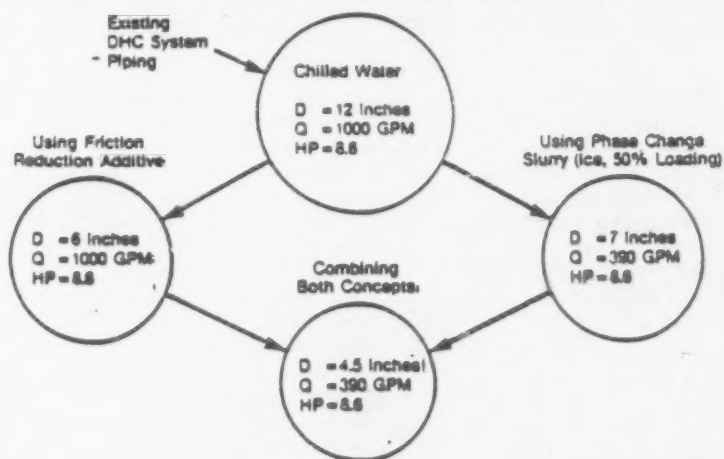
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As the accompanying figure indicates, advanced DHC transmission fluids will have a critical impact on the capital and installation costs of DHC piping systems which can comprise 50-75% of the cost of a DHC system. Such dramatic cost reductions can only accelerate the penetration of cogeneration into the buildings sector.

The following technology R&D projects in advanced fluids and ice slurries have been designated as highest priority and are essential to the development of cost effective advanced district cooling technology:

- Advanced Fluids
 - Polymer and fiber friction reduction additives for use in district cooling systems;
 - Surfactants for friction reduction in district cooling;
 - Heat transfer enhancement; and
 - Combined friction reduction/heat transfer enhancement.
- Ice Slurries
 - Ice slurry evaporator development;
 - Direct freeze ice slurry system testing;
 - Ice slurry loading and heat transfer; and
 - Influence of ice crystal size on hydraulic behavior.

Benefits From Using Improved DHC Transmission Fluids



Advanced Cogeneration and Heat-Activated Cooling Technology R&D

Over the last 6 years since the Public Utilities Regulatory Powers Act (PURPA) was unanimously upheld by the Supreme Court 20,000 MW of cogeneration capacity has been installed in the United States. Although cogeneration accounts

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for only 3.5% of total U.S. electric generating capacity, many estimates indicate that cogeneration's market potential is somewhere in the range of 50,000 to 93,000 MW of electrical generating capacity. Most of the cogeneration capacity developed over the last 6 years has been installed in the industrial sector. Only about 100 to 150 MW have been installed in the form of "packaged cogeneration systems" in the buildings sector, i.e. commercial, residential and institutional buildings. Yet, most estimates of the market potential for cogeneration in the U.S. have indicated that the buildings sector holds at least as much promise as the industrial sector, perhaps as much as 25,000 to 46,500 MW. If this potential is to be tapped, advanced cogeneration and heat activated chilling technologies have to not only be developed but also integrated with advanced district cooling technologies to form optimized systems.

Without advanced district cooling technology, cogeneration systems must be designed to supply the thermal needs of individual buildings. This has proven to be a very unsuccessful approach in the U.S. which is evidenced by the very small amount of cogeneration capacity actually installed to serve the American buildings sector in recent years. However, in many European countries which have substantially more cogeneration capacity than the U.S. the extensive development of district heating has proven essential to the market penetration of cogeneration. Recent DOE studies have corroborated the European experience by concluding that district cooling is essential to the market penetration of cogeneration into the American buildings sector.

The ability of district cooling systems incorporating advanced cogeneration and heat activated chilling to achieve dramatic energy savings as well as a number of critical environmental benefits should not be underestimated. This is apparent from an advanced district cooling technology study in New Orleans which is currently being supported by the DOE District Heating and Cooling Program. The New Orleans District Cooling Project incorporates a cogeneration system (37% efficiency), a high efficiency ammonia chiller with a Coefficient of Performance (COP) of 6.0 and a double effect absorption chiller (COP 1.0) for an overall COP of 2.7. This advanced district cooling system design can achieve an impressive energy efficiency advantage of at least 38% over the conventional alternative since the conventional system achieves an overall maximum system COP of only 1.75 after electrical generation, transmission and utilization efficiencies in a state-of-the-art electric chiller are accounted for. If the advanced district cooling system is compared with average electric building chillers with an overall system COP of 1.0, then the efficiency advantage is as much as 63% over the conventional alternative.

In addition, ammonia chillers and lithium bromide absorption chillers do not use chlorofluorocarbon (CFC) refrigerants which are responsible for atmospheric ozone depletion when released into the air. Such systems offer an alternative to the use of "drop-in" refrigerants designed to replace CFC in existing chillers, the use of which is accompanied with an efficiency penalty of as much as 20%. Building codes prohibit the use of ammonia refrigeration systems inside non-industrial buildings due to the possible toxic effects of the gas if ever released in large amounts in a confined space with people present and unable to escape in a short time. However, ammonia can be used outside buildings under the tightly controlled conditions of a central district cooling and cogeneration plant and in this manner can be used to substitute for building chillers using CFC's.

Advanced district cooling, cogeneration, and non-CFC absorption and ammonia chillers can achieve dramatic increases in energy efficiency and reductions in carbon dioxide emissions while substituting environmentally benign refrigerants for CFC. Thus, these systems offer the prospect of a cost effective, market driven approach to simultaneously alleviating global warming and atmospheric ozone depletion. In addition, such systems can be made commercially available within only a few years given sufficient support for technology research and development.

A number of technical opportunities have been identified which offer excellent potential for developing advanced cogeneration and heat activated cooling systems to the point of commercial viability and incorporating these systems into advanced district cooling systems serving the buildings sector. The highest priority R&D projects identified were as follows:

- Heat activated cooling technology for use with small to intermediately scaled (100kw to 1MW) gas and oil fired diesel engine cogeneration systems:
 - Double effect absorption chiller of American design and manufacture for use in gas fired diesel engines with a coefficient of performance (COP) of 1.2;
 - Triple effect absorption chiller with a COP of 2.0, the theoretical basis of which has been established by Oak Ridge National Laboratory;
 - Jet refrigeration technology (COP 0.6 to 0.8) which offers a low cost solution for intermittent building cooling loads as well as possible automotive air conditioning applications; and
 - Bottoming cycle turbines which can boost cogeneration electrical generation efficiencies by 3 to 4%.
- Reduction of emissions from gas and/or oil fired diesel engine cogeneration systems:
 - Reduction of nitrous oxide emissions using water injection technology.

Renewable Energy Technologies For District Cooling Supply

The use of renewable energy for building air conditioning has the potential to achieve a nearly total elimination of CFC refrigerants and almost complete reduction of carbon dioxide emissions attributable to the generation of building air conditioning supplies. District cooling technology constitutes one of the few means available now or in the future to supply cities with economical air conditioning from renewable energy sources.

Renewable sources of cooling for district systems are ubiquitous as they are located in virtually every climatic region of the United States from the hottest to the coldest. However, all such sources can be most economically tapped at relatively large scales of application. Conversely, in many cases the use of renewable sources of cooling in individual buildings or even small groups of buildings is not technically possible making district cooling essential if these sources are to be used to any great extent. Given sufficient technological development, renewably supplied district cooling systems have the potential to provide most of the energy required for building air conditioning in most American cities. The renewable energy technologies which have the greatest potential for supplying economical district cooling and which should be given highest priority in future technology research and development programs are as follows:

- Freecooling using cooling towers for the production of chilled water for supplying district cooling during the winter months or for long term storage in aquifers until summer. When ambient air temperatures drop to levels required for cooling supply, cooling towers use the air to directly produce chilled water, by-passing the compressor and saving the energy required to run it.
- Spray ponds for the production of low cost cooling supplies from cold winter air. Chilled water produced from spray ponds can similarly be stored in aquifers until required for district cooling.
- Ice ponds for generating low cost district cooling by producing very large amounts of ice by spraying fine droplets of water into cold winter air and collecting ice in large piles. This process can generate cooling at 10% of the energy required for conventional electrically operated chillers.
- Surface waters with cold water located at relatively great depths near shorelines. This source can be tapped for inexpensive district cooling supplies and is available throughout the year in several of the Great Lakes and in the Atlantic and Pacific Oceans especially near Miami, San Diego and Honolulu. River water can also be used during the winter months to directly supply cooling or it can be stored for use later in aquifers.

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In Honolulu, Hawaii, the DOE DHC Program is supporting the study of an advanced district cooling system which proposes to use cold ocean water to supply district cooling initially for Waikiki Beach and later for the entire city of Honolulu. This project will consider the feasibility of building an undersea pipeline several miles in length and 1400 feet below the surface to obtain cold seawater at about 42 degrees F which is available at that depth on a constant basis. This temperature is precisely the level required for district cooling.

A dense area of hotels around Waikiki Beach is the initial focus of the study which if successful could be extended to other dense commercial and residential areas of Honolulu. The proposed Honolulu Seawater District Cooling Project exhibits an 85% energy efficiency advantage over the competition--oil fired utility steam turbine power plants supplying electricity to single building chillers. Thus, this project has the potential to eliminate 85% of the carbon dioxide associated with energy consumption for air conditioning and 100% of the CFC refrigerants in areas where it is applied.

The project will provide a number of other benefits including access to air conditioning at relatively low, stable costs; substitution of locally available renewable energy sources for imported oil; and the achievement of a measure of energy security oil import dependent Hawaii. Furthermore, a number of American cities located along the Atlantic and Pacific coasts have similar opportunities to use cold seawater in direct or precooling district cooling applications. Thus, the Honolulu Seawater District Cooling Project could be the first of many such renewable district cooling systems.

In conclusion, if the United States is to meet the environmental challenges of global warming and atmospheric ozone depletion it will have to make a substantial commitment of funding to develop those technologies which offer real potential for the resolution of these problems in the near future at costs and with methods which are acceptable. There are few, if any, energy supply technologies which can be readied in the short term to successfully overcome these challenges more cost effectively and more rapidly than advanced district cooling technologies incorporating cogeneration, heat activated cooling and renewable energy technologies. If the United States is to develop and implement a successful program for overcoming the challenges of global warming and atmospheric ozone depletion it will be essential for this program to incorporate provisions for supporting the accelerated development of district cooling technologies. Although S 324 provides for only a relatively small amount of funding for district cooling technology R&D, its recognition that district cooling has a significant role to play in addressing global warming and atmospheric ozone depletion problems constitutes a commendable step in the right direction.

U.S. ENERGY DEMAND: BACK TO ROBUST GROWTH?

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Energy Efficiency Issues Paper No. 1¹
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I. Background

Total energy demand in the U.S. fluctuated between 70 and 79 Quads per year during 1973-86 (see Figure 1). However, the 74.3 Quads of energy consumed in 1986 were almost identical to the amount of energy consumed in 1973. Gross national product (GNP) grew by 36% during this same period, representing a 26% decline in national energy intensity. On average, energy intensity declined by 2.3%/yr during 1973-86. Had this reduction in energy intensity not occurred, the nation would have consumed over 100 Quads in 1986 and consumers would be spending at least \$160 billion per year more on energy. Air pollution, climate change, dependence on oil imports, and other problems associated with excessive energy use would be far worse than they now are. In short, energy efficiency improvements have been our most important new energy resource since 1973 and have yielded enormous benefits.²

After more than a decade of declining national energy intensity, the overall energy efficiency of our nation has stalled (see Figure 1). Energy use rose about 8% during the past two years, in tandem with GNP growth. If the energy demand

¹This paper is the first in a series of energy efficiency issues papers being prepared by the American Council for an Energy-Efficient Economy. Support for the series has been provided by the Educational Foundation of America, John A. Harris, IV, and the John D. and Catherine T. MacArthur Foundation.

²National energy efficiency is used in the broad sense of the term including structural shifts within the economy, behavioral changes, and technological changes.

patterns observed in the first nine months of 1988 were sustained, the U.S. consumed around 80 Quads of energy last year. In all likelihood, energy use in 1988 will exceed the previous high of 78.9 Quads reached in 1979. Moreover, energy use per unit of GNP will have risen for the first time in over a decade (see Figure 2).

The jump in energy use and upturn in energy intensity in the past two years has adversely affected the nation in a number of ways:

- o Consumers are already paying about \$30 billion per year in higher energy bills;
- o Carbon emissions from fossil fuel combustion have increased by over 100 million tons (7.3%) in just two years, thereby accelerating atmospheric warming due to the greenhouse effect;
- o U.S. oil imports increased by 22% over the past two years, mainly as a result of increased energy demand;
- o Acid rain emissions are higher and urban smog has worsened.

Given the surge in energy demand in the past two years, it is important to examine underlying factors such as weather, energy prices, manufacturing output, the stock of buildings, vehicle usage, and efficiencies. Changes in these areas explains why energy demand has risen, and provides insight regarding whether energy demand and energy intensity are likely to keep increasing, remain steady, or fall back.

II. Factors Influencing Recent Energy Demand Growth

The analysis presented below examines the changes in energy consumption and the factors contributing to these changes between the first half of 1988 and the same period in 1987. Reasonably comprehensive data are available concerning energy use, activity levels, and other relevant factors during these two recent time periods. After reviewing overall energy use, each end-use sector is examined.

The latest data compiled by the Energy Information Administration show a 5.0% increase in primary energy demand in the U.S. between the first half of 1987 and the first half of 1988 (1). Daily energy demand was 4.5% higher in the first half of

1988 relative to the same period in 1987.³

Table 1 shows the rates of increase by fuel type and sector between the first half of 1987 and 1988. Of the three major fossil fuels, natural gas consumption grew most rapidly (6.9%). But coal use grew almost as fast (6.4%), and oil use also rose substantially (3.4%). The latter is equivalent to an additional 550,000 barrels of oil per day. Regarding end-use sectors, buildings energy demand grew the fastest (5.9%), followed by industry (5.1%) and transportation energy use (3.6%). In addition, electricity production and sales increased by about 4.7% between the first half of 1987 and 1988. Residential electricity demand rose 4.4%, commercial demand rose 6.1%, and industrial demand rose 5.2%.

A. Buildings

In the buildings sector, the 15.4 Quads of primary energy consumed in the first half of 1988 was 5.9% greater than energy use in the same period in 1987 (1). Natural gas use rose 9.3%, petroleum products rose 5.9%, and electricity use 4.5% between these two time periods. It appears that residential energy use increased about 5.5% and commercial buildings energy use about 6.5%, although complete data on the two sectors are not available yet.

Regarding residential buildings, the Bureau of Census reports 91.1 million occupied housing units as of March, 1988. This is 1.8% higher than the level in March, 1987 and 2.9% greater than the number of housing units as of March, 1986. Thus, residential energy use per household increased about 3.6% between the first half of 1987 and the first half of 1988.

Regarding commercial buildings, service sector employment was up about 4.0%

³The rate of increase in total energy demand is greater than daily energy demand because 1988 was a leap year.

from June, 1987 to June, 1988 (2). Thus, commercial sector energy use per employee rose about 2.4% between the first half of 1987 and 1988. In contrast, commercial sector energy use per service worker fell about 0.7%/yr on average during 1970-87. Similar data concerning commercial floor space are not available, but the 1986 NBECS survey by the Energy Information Administration showed that total commercial buildings floorspace increased 2.6% per year on average during 1984-86 (3). If growth continued at this rate in 1987-88, commercial energy per unit of floor area would have risen about 3.8% in the past year.

The decline in energy prices in recent most likely has affected energy use in buildings. The average price of natural gas to residential consumers fell 22% in real terms between 1983 and the first half of 1988 (1). The average price of electricity to residential customers fell 13% in the same time period, with the largest drop in 1986 when oil prices collapsed. For commercial customers, the average price of gas and electricity fell about 28% and 18%, respectively, during this five-year period. Given that econometric studies estimate a short-run residential price elasticity of about -0.20 (4), a portion of the increase in buildings energy use can be attributed to falling energy prices.

Weather conditions are another factor affecting buildings energy demand. Population-weighted heating degree-days in the first six months of 1988 were nearly 10% greater compared to the same period last year (5). Since space heating accounts for about 39% of primary energy use in buildings (6), the increase in heating degree-days may have accounted for about 0.6 Quads of additional energy use in the first half of 1988 compared to the same period in 1987.⁴ This is equivalent to about 70%

⁴The estimated increase in energy use in the first half of 1988 due to the rise in heating degree-days is $0.39 \times 15.4 \text{ Quads} \times 0.10 = 0.6 \text{ Quads}$.

of the 0.86 Quad increase in total buildings energy use that actually occurred.

The number of heating degree-days in the first half of 1988 were not greater than what is considered normal, however (5). In other words, weather in the first half of 1987 was unusually warm, and temperatures returned to normal in 1988. Thus, space heating cannot be expected to rise or decline in the future on account of weather conditions in 1988.

Population-weighted cooling degree-days in the first half of 1988 were very similar to what is considered normal but were 15% less than the level in the first half of 1987 (5). About one-third of cooling degree-days normally occur in the first half of the year and cooling represents about 9% of energy use in buildings (6). So this factor may have reduced energy use in the first half of 1988 by up to 0.13 Quads relative to the same period last year.⁵ However, the actual impact may be smaller because a significant fraction of cooling is caused by internal loads rather than hot weather.

The upturn in energy use in buildings is not due to a stagnation or retreat in equipment efficiency, at least in the residential sector. In fact, the efficiency of most types of major residential appliances has continued to improve in the past few years in spite of falling energy prices (7). For example, the average efficiency of new refrigerators rose 9.4% in 1987 (see Figure 3). This high rate of improvement is attributed to the new efficiency standards that took effect in California in 1987 and upcoming federal standards (7).

As a result of efficiency improvements during the past decade, appliances now being purchased and installed are significantly more efficient than either those being

⁵The estimated reduction in energy use in the first half of 1988 due to the drop in cooling degree-days is $0.33/0.5 \times 0.09 \times 15.4 \text{ Quads} \times 0.15 = 0.13 \text{ Quads}$.

retired or average models in the building stock. For example, the typical new refrigerator or freezer uses about 25% less electricity than the average model in the housing stock, while the typical new air conditioner or furnace uses about 15% less energy than the average in the stock (6). Similar trends appear to be occurring in commercial buildings -- less energy is consumed per unit of floor area in new buildings compared to old buildings (8). Also, use of energy-efficient lamps, ballasts, fixtures, and lighting controls is expanding and is affecting electricity use in commercial buildings as a whole (3, 6).

In summary, growth in the building stock and weather variations explain the nearly 6% rise in energy use in buildings between the first half of 1987 and 1988. Improvements in equipment efficiency are continuing and are preventing even greater increases in energy use.

B. Transportation

In the transportation sector, the 10.7 Quads of primary energy consumed in the first half of 1988 was 3.6% greater than energy use in the same period in 1987 and about 15% greater than energy use in 1983. Transport energy use per household rose about 7% since 1983. Light duty vehicle (cars and light trucks) account for 80% of highway energy use and 63% of total transportation energy use (9).

Falling gasoline and diesel fuel prices have affected transportation energy use. Corrected for inflation, the average retail gasoline price in the first half of 1988 was 27% less than that in 1985 and 48% less than that in 1980. Given this price collapse, it is remarkable that transportation energy use has not risen even more rapidly.

The amount of vehicle use is a key factor affecting transportation energy use. The Federal Highway Administration conducts traffic monitoring at approximately 4000 locations nationwide in order to estimate vehicle-miles travelled (VMT). Their most recent data show a 3.7% rise in VMT for all motor vehicles in the first half of

1988 relative to the same period last year (10). This increase is in line with the 3.4%/yr average annual increase in VMT during 1980-87 (11). The 31% total increase in vehicle use during 1980-88 has more than offset the rise in efficiency of the vehicle stock. Regression analysis shows that vehicle use has been rising in almost direct proportion to real disposable income per capita during the past 30 years (12).

In physical terms, the growth in VMT since 1980 is due primarily to growth in the number of vehicles, although the average miles travelled per vehicle per year increased about 10% during 1980-87 (11). One factor underlying the growth in VMT is the trend towards more single occupancy trips. The average number of passengers in cars (weighted by miles travelled) dropped from 2.16 in 1970 to 1.79 in 1980 and then 1.70 in 1985 (9). There are obvious limits to how far vehicle occupancy levels can fall, but further reductions cannot be ruled out.

Vehicle fuel economy also affects transport energy use. Table 2 shows the fuel economy ratings of new light duty vehicles produced since 1975. After rising 8.0%/yr on average during 1975-80 and 2.1%/yr on average during 1980-85, the rated fuel economy of new light vehicles hardly improved during 1986-88 (13). This is due to both a lack of improvement within vehicle categories and the growing market share of light trucks. Light trucks, which are now 25% less efficient than cars on average, accounted for about 30% of light vehicles sales in 1988 (13). Trucks represented only 20% of new light vehicles in 1980 and 15% in 1970 (9).

The Corporate Average Fuel Economy (CAFE) standards established by Congress in 1975 helped to raise new car efficiencies in the past. Figure 4 shows the average fuel economy of new domestic and imported autos in relation to the CAFE standards along with gas prices since 1973. Even with the steep decline in gasoline prices during the 1980s, the fuel economy of domestic autos continued to rise in close proximity to the CAFE requirements. The CAFE standard for new autos was rolled

back from the original 27.5 mpg to 26.0 mpg for the 1986-88 model years and to 26.5 mpg for the 1989 model year. These actions were accompanied by a levelling off in fuel economy.

At a rated fuel economy of 28 mpg, new cars are still about 25% more efficient than typical models in the vehicle fleet. This differential is responsible for about a 2%/yr increase in the average fuel economy of all passenger vehicles during 1984-87 (11). And since the vehicle fleet takes many years to turn over, the immediate effects of modest improvements in new car efficiency are relatively small. For example, if cars produced in 1986-88 were 1.5 mpg more efficient on average (equivalent to the magnitude of the CAFE rollback), gasoline use in 1988 would have been about 1.0 billion gallons less than it actually was.⁶ This represents 1.4% of auto fuel use and 0.6% of total transport energy use. But maintaining improvements in new vehicle fuel economy is essential for limiting growth in transport energy use over the long run.

A third factor affecting transport energy use is the differential between rated and actual efficiency. EPA estimated that the actual fuel economy of new vehicles was about 15% less than the composite EPA rating as of the early 1980s (14). One transportation energy expert estimates that this margin could reach 30% by 2000 (15).

The differential between rated and actual fuel economies for the overall vehicle fleet is increasing due to a number of factors, including: 1) the trend towards more urban driving and less rural driving, 2) growing urban congestion, 3) greater highway speeds, and 4) increasing average vehicle life.

⁶Cars built in 1986-88 accounted for about 35% of auto use (VMT) in 1988 and about 27% of auto gasoline consumption.

o Urban vs. rural driving. FHA data indicate a 63% urban, 37% rural vehicle-miles mix in 1987, compared to a 50/50 split in the mid-1960s and a 55/45 split for determining the EPA composite fuel economy rating (11). Urban driving tends to be less efficient than rural driving because of shorter trips, more stopping, and less efficient speeds.

o Urban congestion. Tests show that fuel economy falls off below about 30 mpg. Increasing urban congestion leads to more stop-start driving, more engine idling, and lower speeds, each of which reduces fuel economy.

o Highway speeds. Although data are not available on typical highway speeds, repeal of the 55 mph speed limit will lead to greater gasoline use. Tests of 15 different light vehicles indicate a 18% reduction in fuel economy when speed is increased from 55 to 65 mph, and a further 20% reduction in fuel economy when speed is increased from 65 to 75 mph (9).

o Vehicle life. The average age of autos increased from 5.6 years in 1970 to 7.6 years by 1986 (9). Not only are older, less efficient vehicles remaining in use longer, but there is some deterioration in efficiency as vehicles age.

The issue of actual versus rated vehicle efficiency is complex and data are limited. Although the trend is towards an increasing differential, it is difficult to estimate recent changes in a quantitative manner.

In summary, transport energy use increased at a rate that was close to the estimated increase in motor vehicle-miles travelled between the first half of 1987 and 1988. The average fuel economy of the light vehicle fleet is still rising due to new vehicles being more efficient than older vehicles, but new vehicles are no longer improving from year-to-year. Also, the differential between rated and actual fuel economy appears to be growing.

C. Industry

In the industrial sector, the 14.3 Quads of primary energy consumed in the first half of 1988 was 5.1% greater than energy use in the same period in 1987 (1). Coal use was up 8.6%, natural gas use was up 6.8%, oil use was up 2.2%, and purchased electricity was up 5.2% during this period. The increase in industrial energy consumption in 1987 as well as 1988 breaks with the trend of 1973-86 when total industrial energy use declined in spite of growing industrial output (1).

The resurgence of manufacturing is the primary reason for the increase in industrial energy consumption. The Commerce Department reports durable goods production up 13.5% in the first half of 1988 compared to the first half of 1987 (based on constant dollar value), while services were up only 2.5% and total GNP was up 4.5% (19). This pattern breaks with the trend of the 1970s and early 1980s when services expanded more rapidly and durable goods less rapidly than the economy as a whole. Manufacturing, especially production of basic materials, is much more energy intensive than service activities.

Table 3 shows the increase in the physical production of major energy-intensive materials between the first half of 1987 and 1988. Production of steel and aluminum both rose about 17% in this period, while production of other basic materials rose 3-6%. The growth in domestic steel production was accompanied by a 7% increase in steel imports, while the growth in aluminum production was accompanied by a 7% reduction in imports. The latter explains only 16% of the absolute increase in domestic aluminum production. Thus, declining imports do not explain the large increase in primary metals production. In general, metals producers are still recovering from the deep recession that hit these industries in the early 1980s.

Growth in steel and aluminum production increased energy use in the first half of 1988 by about 0.25 Quds compared to energy use the first half of 1987.⁷ This increase in energy use is equivalent to about 35% of the total rise in industrial energy use during this period.

Expansion of industrial cogeneration and self-generation is also contributing to growing industrial energy consumption. One data base shows 24,800 MW of operating

⁷ Additional energy use from steel and aluminum production is estimated using the average energy intensities of each industry as of 1987.

cogeneration and small power production capacity as of 1988, with 5,600 MW added in 1988 alone (22). Cogeneration and self-generation lead to an overall reduction in national energy use, but they inflate industrial energy use while reducing fuel consumption by electric utilities (23).

Industrial energy prices fell more than residential and commercial energy prices in recent years. Between 1983 and the first half of 1988, industrial customers on average saw their real prices for natural gas, electricity and residual fuel oil fall 39%, 19%, and 55%, respectively. These price reductions probably are affecting industrial energy efficiency efforts.

The paper industry, for example, reports a 2.3% increase energy use per unit of output in 1987 (24). The steel industry, on the other hand, reports a 4.3% annual average reduction in energy use per unit of output during 1984-87 (25). Efficiency gains in the steel industry are coming primarily from modernization efforts aimed at improving product quality, output, and providing other benefits along with greater energy efficiency (26). Thus, recovery and expansion within the industry does not result in equivalent growth in energy demand. But steel companies and other energy-intensive industries are not adopting conservation measures for energy savings alone (26).

In summary, recent growth in industrial energy use is attributed to the strength of basic manufacturing industries, particularly primary metals producers. Industrial energy prices have fallen substantially in recent years and have probably affected conservation efforts. However, comprehensive energy efficiency data are not available.

III. Outlook for the Near Future

The question remains as to whether U.S. energy use and energy intensity will continue rising, stagnate, or begin to fall once again. The answer depends on many

factors, as indicated in the discussion above. Some factors behind the recent rise in energy consumption, such as growing vehicle use, are likely to continue in the near future. Other factors, such as the increase in heating degree-days in early 1988, are one-time effects that will not be repeated if conditions remain normal.

By considering ongoing trends and near-term expectations for many of the factors discussed above, it is possible to estimate how total energy use might change in the next five years. In making these estimates, it is assumed that no dramatic changes in energy prices will occur in the near future, in accordance with government and other forecasts.⁸ As a further caveat, the intent is to indicate near-term trends rather than to present a rigorous analysis.

A. Buildings

The nation's housing stock is expected to increase around 1.4%/yr and commercial floor space around 2.0%/yr during the next 5-10 years (6). Proliferation of more energy-efficient appliances, lighting products, windows, and other technologies should hold down growth in buildings energy demand. On the other hand, new end uses (e.g., growth in the use of microcomputers and other electronic equipment) could offset some of these efficiency gains (28).

Overall, with stable energy prices, normal weather, and existing policies, primary energy use in buildings might increase in the vicinity of 1.0%/yr in the near future (6). This rate of increase, roughly what was experienced during 1975-85, implies relatively constant buildings energy use per capita and declining buildings energy use per unit of GNP.

⁸For example, the Energy Department predicts that, corrected for inflation, oil and natural gas prices will increase on the order of 10% and electricity prices will fall slightly over the next five years (27).

B. Transportation

A number of factors including growing vehicle use, a levelling off in the rated fuel economy of new vehicles, and shifting driving patterns are increasing transportation energy demand. Vehicle-miles travelled are projected to increase around 2-3%/yr during 1985-2000 (13). This rate of growth is less than in the recent past because of saturation related to the baby-boom generation reaching driving age and women entering the work force.

The prospect for improving the rated fuel economy of new vehicles in the near future is not promising even though numerous technical options are available to manufacturers (15). In September, 1988, the Transportation Department reduced the auto CAFE standard for the 1989 model year from the original 27.5 mpg to 26.5 mpg in accordance with requests from various auto producers (16). Similar action is expected for the 1990 model year. Moreover, auto producers predict that the average fuel economy of their new car fleets will remain constant or even drop slightly in the near future (16).

Because new cars and light trucks are still about 25% more efficient than the fleet average (based on on-road performance), the fuel economy of the entire vehicle fleet will continue to rise. But the stagnating efficiency of new vehicles and the increasing differential between rated and on-road fuel economies will limit efficiency improvements in the entire vehicle fleet. Given current trends, the fuel economy of the entire vehicle fleet might rise around 1%/yr on average during the next five years. Combining this value with the projected growth in VMT, motor vehicle energy use might increase in the vicinity of 1-2%/yr in the near future.

C. Industry

Near-term prospects for energy use in the industrial sector are difficult to predict. If production of durable goods continues to outpace overall economic growth,

industrial energy use could rise significantly. On the other hand, a quick return to service-led expansion and weakening primary materials production could result in flat or even negative growth in industrial energy demand (21).

Production of most energy-intensive materials is expected to increase in the next five years, although not as rapidly as in 1987-88. Table 3 shows the anticipated average growth rates for the basic materials industries during 1989-93 (20). These industries account for about 70% of manufacturing energy use. Weighting the projected growth rate for each industry according to its share of manufacturing energy use leads to an energy-weighted growth rate of about 1.5%/yr.

Given the lack of interest in energy conservation per se and the slow rate of industrial modernization, industrial energy intensities might remain stable or decline slightly. Consequently, overall industrial energy use could increase in the vicinity of 1.0-1.5%/yr in the short run. But the long-term trend indicates a shift away from basic materials processing, and this should moderate growth in industrial energy demand over the long run (21).

D. Overall

Combining the estimates of near-term energy demand growth in each sector leads to a 1.0-1.5%/yr overall rate of energy demand growth. The base case growth rate projected by the Energy Information Administration for 1989-1995 in its 1988 forecast (1.3%/yr) falls within this range (27). If energy demand increases 1.0-1.5%/yr on average in the near future, U.S. energy consumption will reach 86-89 Quads by 1995. This rate of energy demand growth combined with GNP growth in the vicinity of 2-3%/yr implies slowly declining national energy intensity.

In summary, the large increases in energy use in 1987-88 are not likely to continue. However, low energy prices, increasing activity levels, and slowing efficiency gains in some areas suggest that energy consumption will rise at a moderate

rate in the near future. Unless steps are taken to restrain energy demand, it is unlikely that the U.S. will reproduce the rates of energy productivity improvement experienced during 1973-86.

IV. Policy Context

Energy demand is affected by forces other than the physical changes discussed above. The federal government, states and other organizations can reduce energy demand by adopting minimum efficiency standards, supporting development and dissemination of more efficient technologies and practices, and by influencing energy prices. Many such policies adopted in the mid-70s helped to reduce national energy intensity during the subsequent decade. Some of the more notable examples include the CAFE standards for automobiles (29), state appliance efficiency standards (30), and federal support for energy conservation research (31).

The federal government, unfortunately, has failed to support and in some cases has impeded energy efficiency improvements during the 1980s. Energy conservation R&D and state and local conservation assistance programs were cut by more than 65% (corrected for inflation), the CAFE standards were rolled back, implementation of national appliance and building efficiency standards was delayed and opposed, and monitoring and reporting on industrial energy efficiency was stopped. Hostility towards energy efficiency on the part of the federal government compounds the effects of falling energy prices, increasing activity levels, and slowing efficiency gains.

On the other hand, rising energy use is not preordained. President Bush and the Congress could set a goal of eliminating energy demand growth and returning to at least the rate of energy productivity improvement experienced during 1973-86. This goal is technically feasible, cost effective, and it does not require personal sacrifice or slower economic growth (32, 33).

Achieving this goal requires new policies to stimulate efficiency improvements in our buildings, vehicles, and factories. In 1988, the American Council for an Energy-Efficient Economy issued a policy agenda that recommended:

- o taxing petroleum products while world oil prices are low;
- o adopting new minimum efficiency standards on vehicles and lighting products;
- o providing financial incentives to consumers and utilities in order to stimulate the adoption of additional conservation measures;
- o expanding research, development, and demonstration of energy-conserving technologies and processes;
- o expanding and improving programs to cut energy use in housing occupied by low-income persons (32).

Other actions such as more stringent building codes, tougher appliance efficiency standards, and energy planning based on minimizing the cost of energy services would complement the policies listed above.

If President Bush and the Congress recommit the nation to greater energy efficiency, energy use in 2000 could fall by one-fifth or more relative to current forecasts. As a result, consumers would save hundreds of billions of dollars, industries would become more competitive, air pollution would be reduced, climate change slowed, and oil imports cut. In addition, by reducing our energy waste, we would set a positive example for other nations. Few actions by President Bush and the Congress could have such wide-ranging benefits.

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Table 1 - Change in Primary Energy Use Between the First Half of 1987
and the First Half of 1988

Sector

Residential and commercial	
buildings	+ 5.9%
Transportation	+ 3.6%
Industrial	+ 5.1%
All	+ 5.0%

Fuel Type

petroleum products	+ 3.4%
Coal	+ 6.4%
Natural gas	+ 6.9%
Nuclear power	+ 17%
Hydroelectric power	- 16%
All electricity sales	+ 4.7%

Source: Energy Information Administration, "Monthly Energy Review," DOE/EIA-0035(88/09), U.S. Dept. of Energy, Dec. 1988.

Table 2 - Trends in the Rated Fuel Economy of New Light Vehicles Sold in the U.S.

Model Year	Combined City/Highway Fuel Economy (miles per gallon)		
	Automobiles	Light trucks	All light vehicles
1975	15.8	13.7	15.3
1976	17.5	14.4	16.7
1977	18.3	15.6	17.7
1978	19.9	15.2	18.6
1979	20.3	14.7	18.7
1980	23.5	18.6	22.5
1981	25.1	20.1	24.1
1982	26.0	20.5	24.7
1983	25.9	20.9	24.6
1984	26.3	20.5	24.6
1985	27.0	20.6	25.0
1986	27.9	21.4	25.7
1987	28.3	21.5	25.9
1988	28.4	21.2	25.8

Source: R. M. Heavenrich and J. D. Murrell, "Light-Duty Automotive Technology and Fuel Economy Trends Through 1988", EPA/AA/CTAB-88-07, U.S. Environmental Protection Agency, Ann Arbor, MI, June 1988.

Table 3 - Change in Industrial Output During 1987-88
and Five Year Industrial Outlook

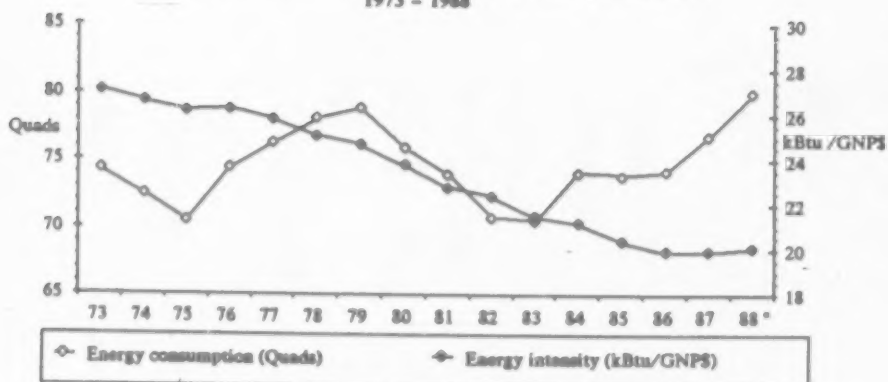
<u>Sector</u>	<u>Change in output, first half of 1987 to first half of 1988 (a)</u>	<u>Annual avg. growth rate, 1989-93 (b)</u>
Primary metals		
Steel products	◊ 17%	- 1%
Aluminum	◊ 17%	+ 1%
Chemicals		
Ammonia	+ 3.8%	} + 2-3%
Chlorine	+ 5.9%	
Plastics and resins	+ 2.8% (c)	
Paper and board	+ 4.9%	+ 3%
Petroleum refining	+ 4.8%	+ 1%

(a) Source: Bureau of Economic Analysis, "Survey of Current Business", Vol. 66, No. 8, U.S. Department of Commerce, August 1988.

(b) Source: International Trade Administration, "1989 U.S. Industrial Outlook", U.S. Department of Commerce, Washington, DC, Jan. 1989. Also, personal communication with Mr. Charles Bell, Office of Basic Industries, U.S. Dept. of Commerce, Washington, DC, Jan. 1989.

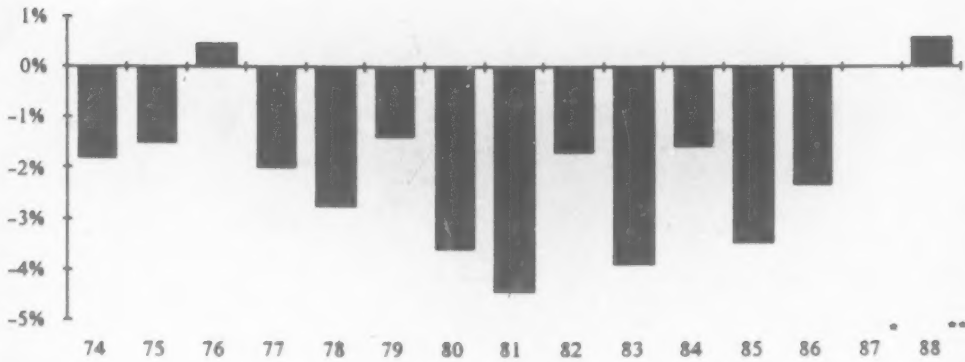
(c) Change between first quarter of 1987 and first quarter of 1988 only.

Figure 1
U.S. ENERGY CONSUMPTION AND ENERGY INTENSITY
1973 - 1988



*1988 data for first three quarters only.

Figure 2
ANNUAL CHANGE IN U.S. ENERGY CONSUMPTION PER \$ OF GNP



Source: Monthly Energy Review, EIA, December 1988

- * No change in energy intensity in 1987
- ** 1988 data for first three quarters only